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Report to the President

Volume III

By The
PRESIDENTIAL COMMISSION
on the Space Shuttle Challenger Accident

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Volume I

Report of the Presidential Commission on the Space Shuttle Challenger Accident

with

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Appendix N—NASA Photo and TV Support Team Report

The facts, circumstances and findings reflected in this report are confirmed as the collective judgment of the individual subteam members. Such confirmation is attested by the following signatures:

Jon D. Erickson

4/17/86
Date

J. Erickson
Lead, Sub-Team
Johnson Space Center

G. M. McDonough

4/17/86
Date

G. McDonough
Lead, Sub-Team
Marshall Space Flight Center

Charles G Stevenson

4/17/86
Date

C. G. Stevenson
Lead, Sub-Team
Kennedy Space Center

Approved: Thomas W Redmond

4/17/86
Date

Thomas W. Redmond
Deputy
Johnson Space Center

DM Germany

4/17/86
Date

D. M. Germany
Lead
Johnson Space Center

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I. EXECUTIVE SUMMARY

The Photo and TV Support Team was established to analyze and document STS 51-L photography and video products. Results were made available to the Failure Analysis Team for use in evaluating failure scenarios. The Photo Team consisted of subteams at Johnson Space Center (JSC), Marshall Space Flight Center (MSFC) and Kennedy Space Center (KSC) that represented the imagery working elements of those Centers and included an independent team leader and a deputy.

The results of the Photo and TV Support Team activities are documented in this comprehensive report, the core of which is the STS 51-L Incident Integrated Events Timeline developed by the team to correlate imagery and telemetry events. This report describes the significant observed anomalies and related events of the STS 51-L accident and includes image enhancement results which were used to identify, locate, and determine time-related characteristics of the events. Conclusions and findings for follow-up efforts are included. A video tape showing significant events was prepared as in interm report. An updated tape is planned which will reflect the final results and will include voice annotation and pictures of selected recovered hardware.

The KSC photographic and TV system consists of 108 film and 69 TV cameras. For this investigation, approximately 13 million frames of imagery were evaluated, including films from previous flights. Additionally, films from private citizens and news media were made available to the team; this help was very much appreciated and letters of appreciation were sent to the contributors.

Although only a few of the events which were analyzed proved to be significant to the investigation, the analysis of the events was vital in establishing the cause of the STS 51-L incident. The primary anomalous events seen in the imagery are the early smoke and later flame issuing from the aft field joint of the right Solid Rocket Booster (SRB). All other anomalous events are the result of the failure indicated by these primary events.

Analysis of the smoke at lift-off was a combination of establishing the probable location, duration and dynamic characteristics of the smoke source. The source was determined to be at or near the aft field joint of the right SRB and circumferentially at approximately 300. This location was inferred geometrically from multiple camera locations since the source was not in the field of view of any camera. Image analysis also established that smoke first appeared at 0.678-second mission elapsed time (MET) and was last visible at 3.375 seconds MET. Frequency of the individual puffs was established (3 to 5 Hz) for comparison with overall vehicle dynamics.

There is no further evidence of the leak until 58.762 seconds MET, when an initially flickering, then steady flame was observed emanating from the right SRB. Photo analysis established its location to be the aft field joint in approximately the same location as the earlier smoke. Flicker frequency was determined to be approximately 10 Hz. (Note: Recovered right SRB hardware shows a burn through at this joint extending from 294° to 316°.)

Dimensions of the leak plume were estimated from the films and were used to support wind tunnel tests to characterize vehicle aerodynamics. Results of these tests were useful for trajectory reconstruction and also helped to explain the observed plume recirculation patterns.

Film analysis also determined the location of the impingement of the SRB leak plume on the External Tank (ET) and the effect of the plume of the resulting liquid hydrogen (LH_2) leak. Film analysis showed the aft end of the right SRB separating from the ET. Geometric analysis of this motion indicates contact of the forward end of the right SRB and the ET intertank area. Finally, details of vehicle breakup and post-breakup characterization of the right SRB were determined. Since telemetry ceased at approximately 73 seconds, imagery and recovered hardware constituted the only evidence of the final destruction of the vehicle.

The activities of the team included analysis of closeout photography of the aft field joint where an initial review had indicated a possible O-ring flaw. Enhancement and mensuration of the film explained the observations and eliminated the concern of an O-ring flaw prior to mating.

In addition to these conclusions and findings, several important lessons were learned during this investigation. The imagery collected as a result of the clear-day weather was very significant in the accident analysis efforts. Had it been a night launch or a launch with an overcast sky, the amount of time required to reach the conclusions drawn would have been much greater and perhaps never as clearly understood. Therefore, launch visibility for photographic reasons should be a primary mission rule until the hardware fixes resulting from this investigation are proved operational.

There is a need for better intercenter and intracenter organization of the photo and TV analysis to support both normal launches and contingency operations. Additionally, camera failures on launch day prevented a clear view of the hardware failure point. More and better cameras are required. Additionally, a review of the types of film used to better aid photo enhancement activities is required. A total review of the requirements for imagery and analysis methodology with a goal of improving imagery acquisition, processing, analysis, and archiving is required.

There is a requirement for the Space Transportation System (STS) program to charter an intercenter photographic/TV working group to document the activities required to implement the findings and conclusions of this report.

II. APPOINTMENT/TEAM CHARTER

The following letter and its attachment establish the Photography and Television Support Team and appoint the Team Lead.

March 20, 1986

51-L DATA AND DESIGN ANALYSIS TASK FORCE

TO: D. Germany
FROM: Task Force Chairman
SUBJECT: Appointment of Lead, Photo and TV Support Team

1. By letter of March 11, 1986, Attachment 1, the Acting Administrator delegated to me, as Chairman of the 51-L Data and Design Analysis Task Force, the power to designate individuals and teams required to support the Task Force. By the same letter, he also delegated to me the power to establish procedures for organization and operation.

2. Pursuant to the delegation, I hereby establish the Photo and TV Support Team of the Task Force and designate you to be the Lead for that Team. The duties, functions and responsibilities of the Team are stated in Attachment 2.

3. As Team Lead, it will be your responsibility:

a. To assign tasks to Team members and coordinate their efforts.

b. To delegate authority to the Deputy Lead to act for you as you see fit with or without you being present at the Team's regular office at KSC. The Deputy Lead will be designated to me or the Vice Chairman.

c. To coordinate the Team's activity with other Team Leads in areas of mutual interest.

d. To consult with the Task Force Vice Chairman on a regular basis on all mutual interests.

e. To prepare, for consideration and approval by the Task Force, documents that memorialize in appropriate formats, the facts and analysis in the Team's assigned area.

Richard H. Truly

Attachments 2

TO: M/Chairman, STS 51-L Data and Design Analysis Task Force
FROM: A/AD/Acting Administrator
SUBJECT: Establishment of the STS 51-L Data and Design Analysis Task Force
REF: Memorandum to M/Associate Administrator for Space Flight from AD/A/Acting Administrator, Subject: Formation of the STS 51-L Data and Design Analysis Task Force, dated February 5, 1986

1. Pursuant to the above reference, the STS 51-L Data and Design Analysis Task Force was created to replace the interim Mishap Investigation Board and to support the activities of the Presidential Commission on the Space Shuttle Challenger accident established pursuant to Executive Order 12546 dated February 3, 1986. The Task Force is established in accordance with NMI 8621.1D and is directed to proceed with the analysis of the facts, circumstances, and design issues surrounding the accident in accordance with the then existing plan and personnel. The purpose of this memorandum is to finalize Task Force membership and responsibilities and establish the powers and responsibilities of the Task Force Chairman.

2. Task Force membership is as set forth in Attachment A.

3. The Task Force is responsible for the following:

(a) Determine, review, and analyze the facts and circumstances surrounding the launch of STS Mission 51-L.

(b) Review all factors relating to the accident determined to be relevant including studies, findings, recommendations, and other actions that have been or may be undertaken by the program offices, field centers, and contractors involved.

(c) Examine all other factors which could relate to the accident including design issues, procedures, organization, and management factors.

(d) Utilize the full required technical and scientific expertise and resources available within the NASA institution and those which are or can be made available to NASA.

(e) Document Task Force findings and determinations and conclusions derived therefrom.

(f) In accordance with procedures established jointly with the Presidential Commission, provide information and documentation to the Commission regarding all the above or any other aspect of Task Force activities.

4. The Chairman of the Task Force is delegated the following powers and is assigned the following responsibilities:

(a) Establish such procedures for the organization and operation of the Task Force as he finds most effective; such procedures shall be part of the Task Force records.

(b) Establish procedures to assure the execution of his responsibilities in his absence.

(c) Direct or require the conduct of special tests or additional research as needed in support of the investigation.

(d) Designate such subgroups, teams, representatives, consultants, experts, liaison officers, observers, or other individuals, as required to support the activities of the Task Force. Their duties and responsibilities shall be included as part of the Task Force records.

(e) Coordinate the activities of the Task Force with the Presidential Commission in accordance with procedures established by the Commission.

(f) In coordination with the NASA Director of Public Affairs, develop a policy for the appropriate review and dissemination of information to the public concerning the Space Shuttle Challenger accident and the activities of the Task Force.

(g) Advise the Administrator concerning the organization, procedures, operations, and findings of the Task Force, and its associated activities as required.

5. All elements of NASA will cooperate with the Task Force and provide full support within their areas of responsibility.

6. By separate action, I am directing the Associate Administrator for Space Flight, consistent with the final report of the Presidential Commission, to undertake through the regular Office of Space Flight organization such reviews, studies, and supporting actions as are required to develop recommendations to me on corrective measures to be taken prior to the next STS mission with respect to hardware, operational procedures and other aspects of the STS program.

William R. Graham
Acting Administrator

Enclosure

ATTACHMENT A

The following personnel are appointed to memberships on the 51-L Data and Design Analysis Task Force.

- Rear Admiral Richard H. Truly, Chairman (Associate Administrator for Space Flight)
- Mr. James R. Thompson, Vice Chairman (NASA Headquarters)
- Mr. Robert Crippen (NASA Astronaut, JSC)
- Col. Nathan Lindsay (Commander, AF Eastern Space and Missile Center)
- Dr. Joseph Kerwin (Director, Space and Life Sciences, JSC)
- Dr. Walter Williams (Special Assistant to the NASA Administrator)
- Mr. Thomas Lee (Deputy Director, MSFC)
- Mr. Clay McCullough (Manager, Support Equipment and Logistics Office, JSC)
- Mr. Thomas Utsman (Deputy Director, KSC)
- Col. Robert Bourne (Director, AF Space Shuttle Operations, VAFB)
- Mr. Alton Jones (Director of Flight Assurance. FSFC)
- Mr. John Thomas (Manager, Spacelab Program Office, MSFC)
- Mr. Tommy Holloway (Chief, Flight Director Office, JSC)
- Mr. Harold Draughon (Manager, Mission Integration Office, JSC)

Mr. Edward F. Parry (Chief Counsel, KSC) will serve as Legal Counsel to the Task Force. Mr. Jay F. Honeycutt (Deputy Manager of Operations and Integration Office, JSC) will serve as Task Force Staff Officer in NASA Headquarters.

Attachment 2

GENERAL ASSIGNMENTS FOR PHOTO AND TV SUPPORT TEAM

The Photo and TV Support Team shall perform as a priority task the end to end 51-L Mission Photography and Video products analysis. The results of these analyses are to be documented and provided to the four Task Force teams that have Commission Panel counterparts. These results will be designed to assist these teams in their efforts to respond to the needs and interests of the Commission. All photographic and TV products will be cataloged, analyzed, and documented.

This Team will serve as the focal point for all of the task force efforts concerning photography and TV including any required enhancement areas.

All requests for photographic and TV products will be handled by this Team. The other Task Force Teams will forward their tasks for photographic and TV data to this team for action.

The Team will assist the Commission panels as required with proper coordination with the interested Task Force Team.

The Team will establish a total photographic and TV plan for support of the task force and commission efforts.

Reporting will be in accordance with Task Force procedures and as required by the Task Force Chairman or Vice Chairman.

III. ORGANIZATION

Figure 1 shows the organization of the Photography and Television Support Team in relation to the STS 51-L Data and Design Analysis Task Force. The figure also lists the number of full-time personnel involved at the NASA Centers and at other processing and enhancement facilities.

FIGURE 1

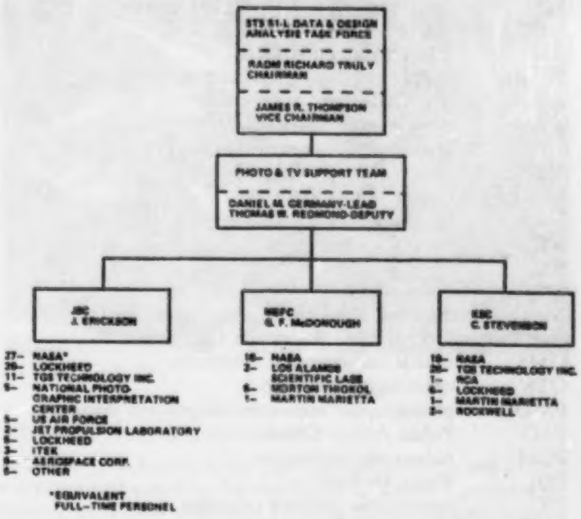

STS 51-L DATA & DESIGN ANALYSIS TASK FORCE
RADM RICHARD TRULY CHAIRMAN
JAMES R. THOMPSON VICE CHAIRMAN
PHOTO & TV SUPPORT TEAM
DANIEL M. GERMANY-LEAD
THOMAS W. REDMOND-DEPUTY
JSC J. ERICKSON
MSFC G. F. McDONOUGH
KSC C. STEVENSON
27– NASA*
20– LOCKHEED
11– TGS TECHNOLOGY INC.
5– NATIONAL PHOTOGRAPHIC INTERPRETATION CENTER
5– US AIR FORCE
2– JET PROPULSION LABORATORY
6– LOCKHEED
3– ITEK
6– AEROSPACE CORP.
6– OTHER
18– NASA
2– LOS ALAMOS SCIENTIFIC LABS
6– MORTON THIOKOL
1– MARTIN MARIETTA
19– NASA
20– TGS TECHNOLOGY INC.
1– RCA
6– LOCKHEED
1– MARTIN MARIETTA
2– ROCKWELL
*EQUIVALENT FULL–TIME PERSONEL

Figure 1 Organization of Photography and Television Support Team

IV. ACRONYMS

AGC	automatic gain control
APU	auxiliary power unit
BET	best estimate of trajectory
CAD	computer-aided design
CCD	charge coupled device
CCR	camera control repeater
CTC	camera timing and control
CZR	ribbon frame cameras
DCU	decimal counting unit
DEMUX	demultiplexer
ECC	emergency camera control
EIU	engine interface unit
EPRCO	Exxon Production Research Company
ET	external tank
ETR	Eastern Test Range
FM	frequency modulated
FR	firing room
FSS	fixed service structure
GMT	Greenwich mean time
GMTLO	lift-off in GMT
GPC	general-purpose computer
GUCP	ground umbilical carrier plate
HPFTP	high-pressure fuel turbopump
HDP	holddown post
Hz	Hertz
IRIG	Inter-Range Instrumentation Group
IGOR	intercept ground optical recorder
IFLOT	intermediate focal length optical tracker
IEA	integrated electronics assembly
JPL	Jet Propulsion Laboratory
JSC	Lyndon B. Johnson Space Center
KSC	John F. Kennedy Space Center

LC	launch complex
LCC	Launch Control Center
LED	light-emitting diode
LIPS	Library of Image Processing Subroutines
LMSC	Lockheed Missiles and Space Corporation
LOA	launch operations area
LOV	limit of visibility
LPS	launch processing system
MCC	Mission Control Center
ME	main engine
MEC	master events controller
MET	mission elapsed time
MIGOR	mobile intercept ground optical recorder
MILA	Merritt Island Launch area
MLP	mobile launch platform
MPS	main propulsion system
MSFC	Marshall Space Flight Center
MTU	master timing unit
MUX	multiplexer
NC	normally closed
NIP	network interface processor
NO	normally open
NPIC	National Photographic Interpretation Center
ODRC	Orbiter Data Reduction Complex
OMS	orbital maneuvering subsystem
OTV	operational television
PA-DD	photographic acquisition-disposition document
PAO	Public Affairs Office
PCM	pulse-code-modulation
PDL	Ponce De Leon
PIC	pyrotechnic initiator capacitor
PM	phase modulated
PPS	pulse-per-second
PSF	pounds per square foot
PRD	Program Requirements Document
PTCR	pad terminal connection room
RCS	reaction control system
RF	radio frequency
RSS	rotary service structure
ROTI	recording optical tracking instrument
RGA	rate gyro accelerometer
RSLS	redundant set launch sequencer
RZ	return to zero
SOP	software operation program
SRB	solid rocket booster
SRM	solid rocket motor
SSME	Space Shuttle main engine
STS	Space Transportation System
T-0	time of mission start, SRB ignition command
TCC	tracker control cabinet
TDRS	tracking and data relay satellite
TMS	trend monitoring system
TSM	tail service mast
TTU	timing terminal unit
TV	television
TVC	thrust vector control
UCS	universal camera sites
USAF	United States Air Force
VAB	vehicle assembly building
VAST	Visual Analysis Support Team
WPAFB	Wright Patterson Air Force Base

V. PHOTOGRAPHIC, VIDEO, AND TELEMETRY DESCRIPTION AND ANALYSIS

A. *Introduction*

This section of the report provides the combined summary results of the photographic analysis teams from the Lyndon B. Johnson Space Center, the John F. Kennedy Space Center, and the Marshall Space Flight Center. Included in this section is a description of the photographic and video systems in place at KSC and the enhancement analysis systems used by the JSC and MSFC photographic analysis teams. The STS 51-L integrated timeline is included. It was developed utilizing the JSC and MSFC evaluation teams in conjunction with the photographic teams at the three Centers. The timeline depicts the events as derived from the available telemetry and photographic data. The special analysis section provides the summary results of the analysis performed on selected photographic data which support the analytical and testing effort being performed by the primary task force teams.

B. *Systems Description*

1. *Photo-Optical System Description*

This section briefly describes and outlines the operational capabilities of the launch operations area (LOA) photo-optical system used at KSC. The subsystems that make up the LOA photo-optical system are listed in the following table.

LOA Photo-Optical System

System Equipment	*Model*
LC-39A Launch Control Center	U72-1159
LC-39A pad, fixed service structure, and perimeter	U72-1042
Mobile launch platform (MLP)	U72-1072

2. *Launch Complex 39/B/MLP-2 Photo-Optical Description*

a. *Background*

The Launch Complex (LC)-39 photo-optical system was conceived in the early days of the Apollo Program in 1963. During the intermediate years of the mid-sixties, the systems design evolved, and installation was complete for the first of the Saturn V launches. The system was an advanced state-of-the-art system at the time.

Although many elements of the system have been upgraded over the years due to unavailability of original parts, and to take advantage of obvious equipment advances, the system is basically the same system.

Since the Shuttle vehicle and ground systems configurations are entirely different from that of the Apollo, the camera locations are different. This is much more apparent around the proximity of the launch mount than it is at the perimeter camera sites.

Photographic coverage of the Shuttle launch vehicle has been implemented per requirements in the Program Requirements Document (PRD) and supported per the Photographic Acquisition-Disposition Document (PA-DD) by the Photographic contractor.

The cameras, environmental housings, most of the mounting hardware, blast covers, and close-in trackers are basically unchanged and have been highly successful thus far in the Shuttle Program.

b. *Photo-Optical System Functions*

One of the most important functions of photo-optical systems is to obtain contingency data, particularly to support detail studies of complex event development, and to detect anomalies.

The LC-39 Pad A and B photo-optical system is designed to command and control the remote operation of an extensive array of engineering and documentary film cameras.

Image data are obtained during prelaunch, flight readiness firing, and launch operations for the study and analysis of ground and flight vehicle systems performance.

Engineering applications include high-speed photography of events such as rocket engine ignition sequences, vehicle release mechanisms, mechanical displacements, and vehicle position and attitude during lift-off.

A wide variety of photographic analysis is performed such as detection and identification of flying debris, physical condition of external surfaces, and correlation of lift-off sequences. In addition to the engineering applications, the system also provides a wide variety of still, rapid sequence, and motion picture cameras for press release, multi-media audiovisual applications, and historical record.

c. *Outline Description of System*

The system control is located in the Launch Control Center (LCC), and incorporates the capability of sequencing up to 160 cameras on each launch pad, including the Mobile Launcher Platform, and the Fixed Service Structure (FSS).

At T-3 minutes, the sequencer is activated and initiates an independent parallel countdown to the Launch Processing System (LPS) countdown, with hold and resume count capability.

At the programmed times, camera start signals are multiplexed and sent to the launch pad, where they are demultiplexed and combined with camera running power and time correlation signals. Distribution to individual cameras is made through repeaters which are centrally located near major camera sites.

d. *System Support Subsystems*

In addition to the cameras, the system is composed of all the associated hardware and equipment such as mounting pedestals, platforms, brackets, and includes special plates, wedges, and adapting devices.

Also included in the support subsystems are the service cables, purge lines, environmental housings, blast covers, pan-and-tilt units, and dovetail quick-release mounts. Remote controls for close-in tracking of initial flight are also a part of the system.

The major equipment in the control system includes patch panels, timing terminal units, camera control repeaters, system sequencer, emergency camera controls, purge panels for safety and window purge multiplexer and demultiplexer (mux and demux) units, data modems, and camera control cabinets.

e. *The 51-L Photo-Optical System Configuration*

(1) *Perimeter Sites*

Figure 2 shows an aerial view of Pad 39-B showing perimeter camera sites.

Figure 3 shows a typical Perimeter Camera Site, specifically Site 4. The figure has been provided for a better understanding of the detailed site data contained in **tables 1 through 5.**

Figure 4, a general view of an LC-39B Perimeter Camera site is included to show the relationship of the camera locations contained in **tables 1 through 5** to the Shuttle vehicle. The camera locations are relative to the vertical axis of the external tank in the launch position.

There is no Site 5 due to the presence of the slide wire installation.

Table 6 shows the displacement of each camera location from the site bench marks shown in **tables 1 through 5.**

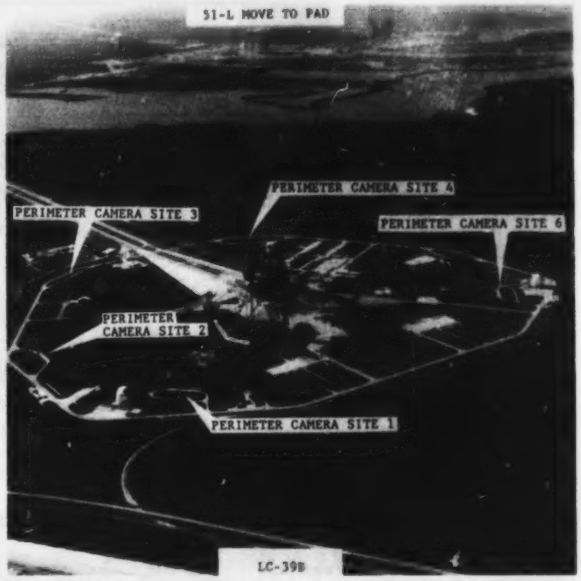


FIGURE 2

(2) *Fixed Service Structure and MLP-2*

The cameras located in the Fixed Service structure and MLP-2 are precisely located on **figures 5 and 6. Table 7** provides the viewing angles and coordinate locations for each of these cameras with reference to the X and Y axes of the external tank in the launch position.

f. *Engineering Description of the System*

A detailed engineering description of the LC-39 photo-optical system is provided as an appendix to this report.

2. *Tracking Camera Coverage*

Shuttle photographic tracking coverage utilizes a series of cameras located outside the pad perimeter which provide coverage from prior to ignition until after SRB separation or until LOV (Limit of Visibility).

Also, at ignition, cameras are started at three off-complex IFLOT (Intermediate Focal Length Optical Tracker) tracking mounts. These mounts are located at Universal Camera Sites (UCS) north, west and south of the launch pad at distances of 3 to 7 miles. These mounts have 16mm and 70mm cameras for coverage of early flight. Although they do provide coverage at lift-off, the lenses are not in proper focus until the vehicle has reached an altitude of approximately 1200 feet. Another mount located 3 miles southeast of the pad provides 70mm coverage of lift-off through the roll maneuver for broadcast-release television.

The long-range tracking instruments are mounted on mobile trailers or stationary units and are linked to the ETR radar and ranger computer. They are identified by type of mount:

MIGOR – Mobile Intercept Ground Optical Recorder
IGOR – Intercept Ground Optical Recorder
ROTI – Recording Optical Tracking Instrument

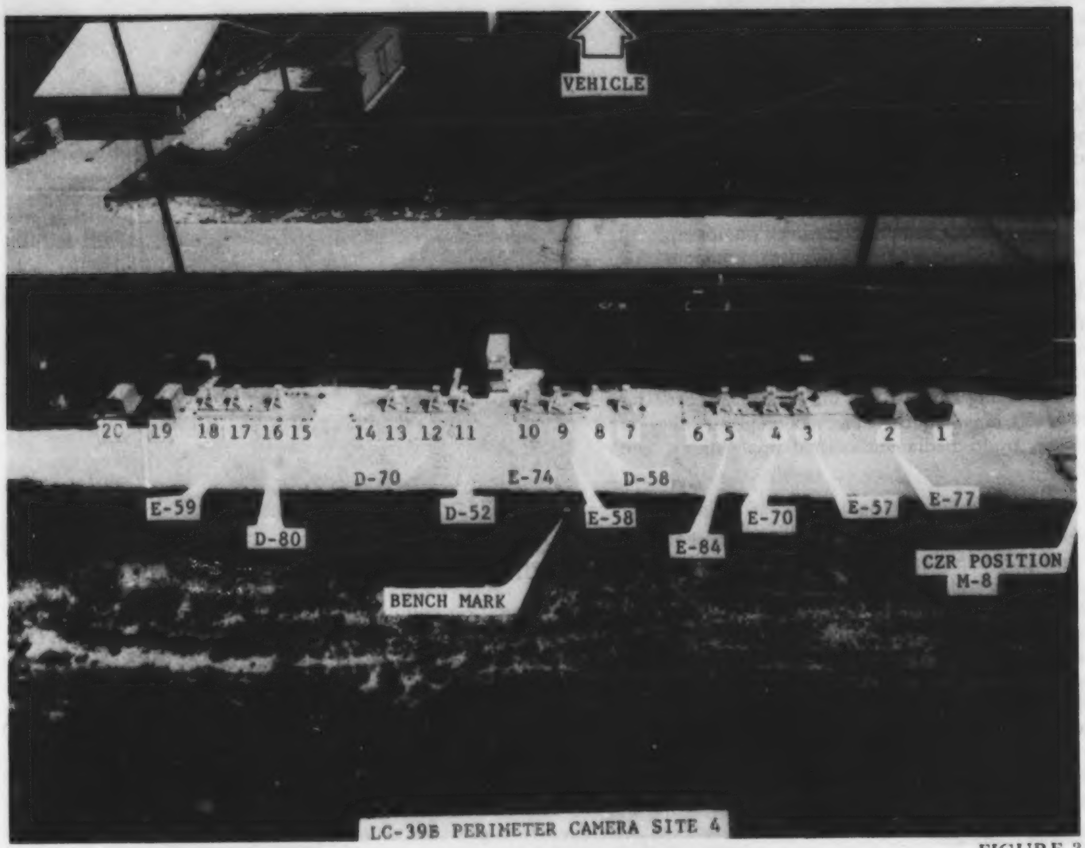

VEHICLE
20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1
D-70
E-74
D-58
E-59
D-52
E-58
E-70
E-57
E-77
D-80
E-84
CZR POSITION
M-8
BENCH MARK
LC-39B PERIMETER CAMERA SITE 4

FIGURE 3

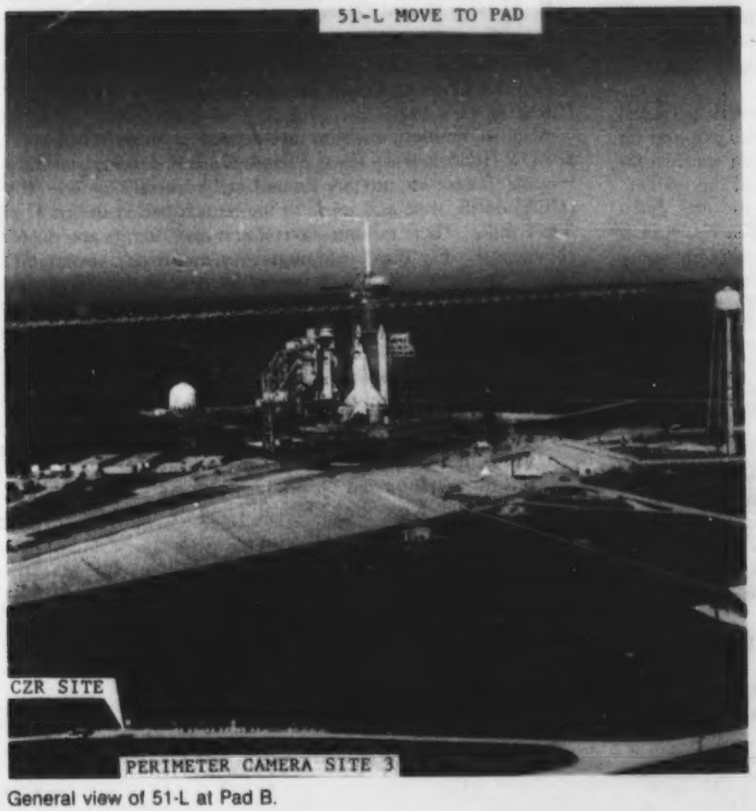
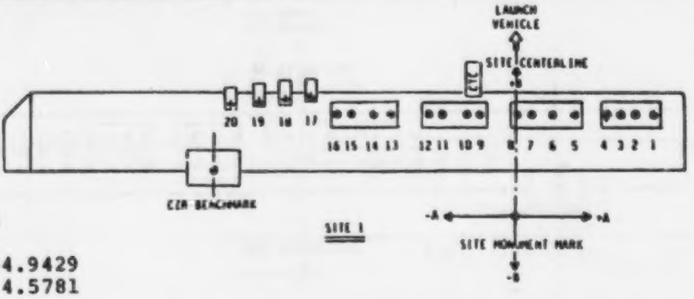

51-L MOVE TO PAD
CZR SITE
PERIMETER CAMERA SITE 3

FIGURE 4

General view of 51-L at Pad B.

TABLE 1 LC-39B Perimeter Site 1 Camera Locations.

SITE	POSITION PED.	POSITION CAM.	ANGLE ℄	DISTANCE (FT.) AZ	DISTANCE (FT.) EL	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
SITE 1	1		48° 29' 15"	1267.32	1269.81								
	2		48° 39' 25"	1267.23	1269.72								
	3		48° 54' 20"	1267.11	1269.60								
	4		49° 03' 57"	1267.05	1269.54								
	5	E-81	49° 25' 30"	1266.94	1269.43	16mm	MIT	25mm	1200' VND	48	AEC	B	MITCHELL
	6		49° 38' 10"	1266.90	1269.39								
	7		49° 46' 56"	1266.88	1269.37								
	8	E-62	49° 54' 13"	1266.89	1269.36	16mm	MIT	32mm	200'VND	100	—	B	MITCHELL
	℄		50° 00' 00"	1266.89	1269.36								
	9		50° 23' 11"	1266.90	1269.39								
	10		50° 31' 45"	1266.93	1269.42								
	11	E-60	50° 46' 55"	1266.99	1269.48	16mm	MIT	32mm	200'VND	100	—	B	MITCHELL
	12		50° 55' 31"	1267.04	1269.53								
	13		51° 19' 57"	1267.22	1269.71								
	14	E-68	51° 28' 46"	1267.30	1269.79	16mm	MIT	25mm	1200' VND	24	AEC	B	MITCHELL
	15	E-72	51° 43' 56"	1267.45	1269.94	16mm	MIT	25mm	1200'	3	—	C	MITCHELL
	16		51° 52' 24"	1267.55	1270.04								
	17	E-50	52° 10' 40"	1262.96	1265.46	16mm	DBMS	8"	200'VND	400	1	A	MILLIKEN
	18		52° 36' 35"	1263.35	1265.84								
	19		52° 45' 28"	1264.04	1266.54								
	20		53° 01' 48"	1264.60	1267.10								

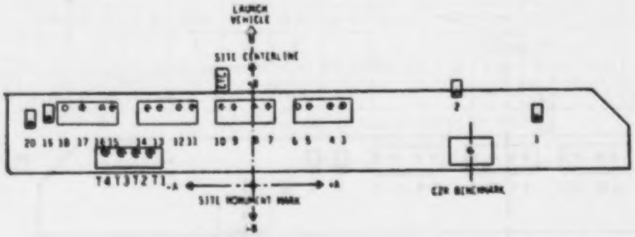


CZR Item M-5

Lat. 28:37:44.9429
Long. 80:37:4.5781

TABLE 2 LC-39B Perimeter Site 2 Camera Locations.

SITE	POSITION PED.	POSITION CAM.	ANGLE ℄	DISTANCE (FT.) AZ	DISTANCE (FT.) EL	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
SITE 2	1		86 27'08"	1290.06	1292.53								
	2		87°24'41"	1282.14	1284.63								
	3	E-79	88°50'53"	1284.25	1286.70	16mm	DBMS	40"	200'VND	100	—	B	MILLIKEN
	4	E-65	89°00'53"	1284.18	1286.63	16mm	DBMS	20"	200'VND	100	—	B	MILLIKEN
	5	E-82	89°15'54"	1284.10	1286.55	16mm	MIT	25mm	1200' VND	48	AEC	B	MITCHELL
	6		TV	—	—	—	—	—		—	—	—	—
	7	E-94	89°47'14"	1284.00	1286.45	70mm	HUL	7"	100' VPS3	10	2	—	HULCHER
	8		89°57'13"	1284.00	1286.45								
	℄		90°00'00"	1284.00	1286.45								
	9	D-60	90°12'16"	1284.00	1286.45	35mm	MIT	35mm	400'ECN	96	2	—	MITCHELL
	10	D-50	90°27'15"	[illegible]	1286.47	16mm	MIT	75mm	200'VND	32	2	—	MITCHELL
	11	D-59	90°42'26"	1284.10	1286.55		HSBLD	150mm	12-PX		2	—	HASSELBLAD
	12	D-56	90°53'27"	1284.15	1286.60	70mm	HUL	7"	100' VPS3	10	2	—	HULCHER
	13		91°06'10"	1284.23	1286.68								
	14		91°16'53"	1284.32	1286.77								
	15		91°40'58"	1284.55	1287.00								
	16		91°51'40"	1284.67	1287.12								
	17		92°04'41"	1284.84	1287.29								
	18		TV										
	19		92°28'25"	1287.95	1290.42								
	20		92°43'29"	1288.66	1291.13								
TRACKERS	T1		91°12'00"	1295.39	1297.67	16mm	DBMS	75mm	400'VND	100	—	B	MILLIKEN
	T2		91°15'00"	1295.42	1297.70	16mm	DBMS	75mm	400'VND	100	—	B	MILLIKEN
	T3		91°19'00"	1295.45	1297.73	35mm	NIKON	A/R	250 VPS	N4		-	NIKON
	T4		91°23'00"	1295.49	1297.77	16mm	DBMS	75mm	400 VND	100	—	B	MILLIKEN



SITE 2

CZR Item M-6

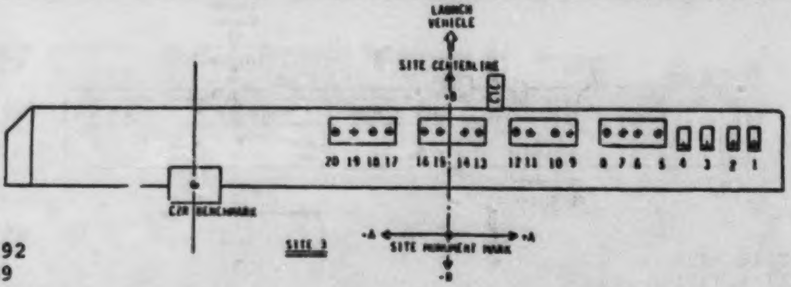
Lat. 28:37:37.5211
Long. 80:37:01.1258

TABLE 3

LC-39B Perimeter Site 3 Camera Locations.

SITE 3

POSITION PED.	CAM.	ANGLE ℄	DISTANCE (FT.) AZ	EL	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
1		146° 47' 17"	1271.51	1274.00								
2		147° 02' 32"	1271.20	1273.69								
3	E-76	147° 18' 07"	1270.92	1273.41	16mm	DBMS	20°	1200'VND	200	—	A	MILLIKEN
4		147° 33' 32"	1270.66	1273.15								
5	E-83	147° 47' 32"	1268.24	1270.73	16mm	MIT	25mm	1200'VND	48	AEC	B	MITCHELL
6		147° 59' 18"	1268.08	1270.57								
7		148° 10' 09"	1267.95	1270.44								
8		148° 21' 01"	1267.82	1270.31								
9	E-61	148° 45' 05"	1267.60	1270.09	16mm	MIT	32mm	200'VND	100	—	B	MITCHELL
10	D-51	148° 54' 19"	1267.53	1270.02	16mm	MIT	25mm	200'VNF	32	2		MITCHELL
11		149° 09' 15"	1267.43	1269.92								
12	D-57	149° 19' 20"	1267.38	1269.87		HSBLD	150mm	12 COLOR	—	2		
13	D-60	149° 41' 06"	1267.31	1269.80	70mm	HUL	7"	100'COLOR	10	2		
14	D-69	149° 51' 16"	1267.29	1269.78	16mm	MIT	25mm	400' 7291	32	2		MITCHELL
℄		150° 00' 00"	1267.29	1269.78								
15		150° 06' 07"	1267.29	1269.78								
16	D-54	150° 15' 25"	1267.30	1269.79		HSBLD	150mm	B&W	1	2		HASSELBLAD
17	E-95	150° 37' 08"	1267.36	1269.85	70mm	HUL	7"	100'VPS2	10	2	—	HULCHER
18	E-69	150° 46' 20"	1267.41	1269.90	16mm	MIT	25mm	1200'VND	24	AEC	B	MITCHELL
19	E-73	151° 02' 20"	1267.49	1269.98	16mm	MIT	25mm	1200'VND	3		E	MITCHELL
20		151° 12' 27"	1267.57	1270.06								



CZR Item M-7

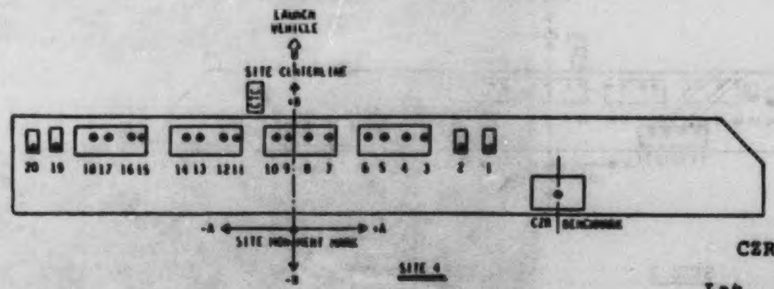
Lat. 28:37:25.0692
Long. 80:37:9.3269

TABLE 4

LC-39B Perimeter Site 4 Camera Locations.

SITE 4

POSITION PED.	CAM.	ANGLE ℄	DISTANCE (FT.) AZ	EL	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
1		207° 59' 19"	1271.23	1273.72								
2	E-77	208° 16' 56"	1271.16	1273.65	16mm	DBMS	20°	200'VND	200	—	A	MILLIKEN
3	E-57	208° 42' 03"	1268.70	1271.19	16mm	DBMS	40mm	200'VND	100		B	MILLIKEN
4	E-70	208° 52' 10"	1268.67	1271.11	16mm	MIT	25mm	1200'VND	24	AEC	B	MITCHELL
5	E-84	209° 07' 28"	1268.28	1270.77	16mm	MIT	25mm	1200'VND	48	AEC	B	MITCHELL
6		209° 16' 07"	1268.48	1270.97								
7		209° 40' 48"	1268.39	1270.88								
8	D-58	209° 51' 51"	1268.71	1271.20	70mm	HUL	7"	100'VPS2	10	2		HULCHER
℄		210° 00' 00"	1268.37	1270.86								
9	E-58	210° 03' 50"	1268.37	1270.86	16mm	DBMS	40mm	200'VND	100	—	B	MILLIKEN
10	E-74	210° 13' 54"	1268.37	1270.86	16mm	MIT	25mm	1200'VND	3	—	E	MITCHELL
11	D-52	210° 35' 45"	1268.44	1270.93	16mm	MIT	25mm	200'VNF	32	2		MITCHELL
12	D-70	210° 45' 41"	1268.48	1270.97	16mm	MIT	25mm	400 7291	32	2		MITCHELL
13		211° 00' 59"	1268.57	1271.06								
14		211° 09' 07"	1268.63	1271.12								
15		211° 33' 58"	1268.84	1271.33								
16	D-80	211° 43' 01"	1268.94	1271.43	35mm	NIKON	A/R	250 COLOR		2		NIKON
17	E-59	211° 58' 09"	1269.12	1271.61	16mm	DBMS	40mm	200'VND	100	—	B	MILLIKEN
18		212° 11' 08"	1269.26	1271.75								
19		212° 29' 59"	1271.53	1274.36								
20		212° 44' 23"	1271.99	1274.93								



CZR Item M-8

Lat. 28:37:25.1032
Long. 80:37:22.5379

TABLE 5 LC-39B Perimeter Site 6 Camera Locations.

	POSITION			DISTANCE (FT.)		FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
	PED.	CAM.	ANGLE ℄	AZ	EL								
SITE 6	1		305°21'32"	1274.54	1277.02								
	2		305°36'45"	1276.49	1274.01								
	3		307° 39' 33"	1271.24	1273.73								
	4		307° 55' 54"	1270.94	1273.47								
	5	E-86	308° 12' 08"	1271.22	1273.70	16mm	MIT	25mm	1200'VND	48	AEC	B	MITCHELL
	6		308° 24' 26"	1272.08	1273.56								
	7		308° 35' 09"	1270.98	1273.46								
	8		308° 45' 58"	1270.89	1273.37								
	9		309° 10' 19"	1270.72	1273.20								
	10		309° 19' 28"	1270.68	1273.16								
	11	E-63	309° 34' 44"	1270.62	1273.10	16mm	MIT	32mm	200'VND	100	—	B	MITCHELL
	12	E-75	309° 44' 46"	1270.60	1273.08	16mm	MIT	25mm	1200'VND	3	—	E	MITCHELL
	℄		310° 00' 00"	1270.58	1273.06								
	13	E-71	310° 05' 31"	1270.58	1273.06	16mm	MIT	25mm	1200'VND	24	AEC	B	MITCHELL
	14		310° 15' 33"	1270.60	1273.09								
	15		310° 30' 54"	1270.63	1273.11								
	16		310° 40' 52"	1270.67	1273.15								
	17		311° 02' 31"	1270.79	1273.27								
	18		311° 09' 40"	1270.51	1273.39								
	19		311° 32' 58"	1271.05	1273.53								
	20		311° 43' 03"	1271.15	1273.63								

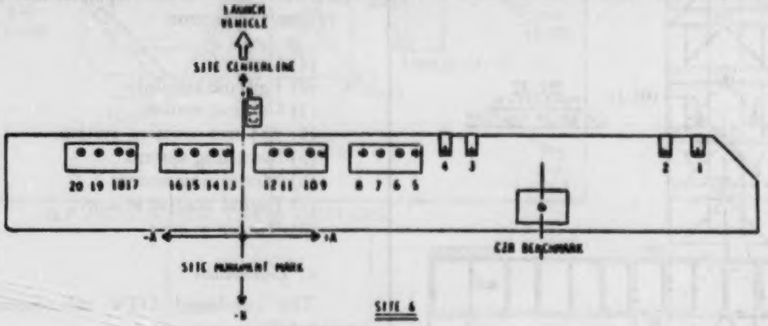


TABLE 6 Dimensional Offsets of Perimeter Camera Stations Except CZR's With Reference to the Benchmarks.

PHOTO-OPTICAL PERIMETER SITE POSITIONS & CAMERA LOCATIONS

SITE 1	Ped.#	1	2	3	4	5	6	7	8	M/M	9	10	11	12	13	14	15	16	17	18	19	20
	A	33.81	30.06	24.56	21.02	13.08	8.41	3.91	0.25	0.00	-8.52	-11.68	-17.29	-20.45	-29.45	-32.70	-38.29	-41.41	-47.95	-53.68	-60.75	-66.75
	B	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	23.12	27.93	27.79	27.41	27.16
SITE 2	Ped.#	1	2	3	4	5	6	7	8	M/M	9	10	11	12	13	14	15	16	17	18	19	20
	A	79.83	57.41	25.83	22.06	16.47	TV	4.77	1.00	0.00	-4.50	-8.31	-16.22	-19.97	-24.72	-28.72	-37.72	-41.72	-46.59	TV	-55.59	-61.26
	B	17.41	24.16	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	21.00	18.25	17.79
SITE 3	Ped.#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	M/M	15	16	17	18	19	20
	A	71.49	65.87	60.12	54.43	49.18	44.85	40.85	36.85	28.35	24.62	19.08	15.31	7.33	3.62	0.00	-2.00	-5.68	-13.68	-17.45	-22.97	-26.70
	B	20.5	20.5	20.5	20.5	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70	22.70
SITE 4	Ped.#	1	2	3	4	5	6	7	8	M/M	9	10	11	12	13	14	15	16	17	18	19	20
	A	44.95	38.45	29.12	25.30	19.75	16.56	7.45	3.37	0.00	-1.41	-5.12	-13.18	-16.85	-22.50	-25.50	-34.66	-38.00	-43.50	-47.41	-56.01	-60.75
	B	19.56	19.41	21.62	21.62	21.62	21.62	21.62	21.62	21.67	21.67	21.62	21.62	21.62	21.62	21.62	21.62	21.62	21.62	21.62	19.33	19.00
SITE 6	Ped.#	1	2	3	4	5	6	7	8	9	10	11	12	M/M	13	14	15	16	17	18	19	20
	A	103.5	97.03	52.26	46.58	40.22	35.68	31.72	27.72	18.72	15.35	9.70	6.00	0.00	-2.04	-5.75	-11.41	-15.12	-23.12	-26.03	-32.49	-36.18
	B	19.66	19.75	19.83	19.91	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41	19.41

LEGEND
A-B = COORDINATES
PED.# = PEDESTAL NO.
M/M = MONUMENT MARK

ALL DIMENSIONS ARE IN FEET & TENTHS OF FEET

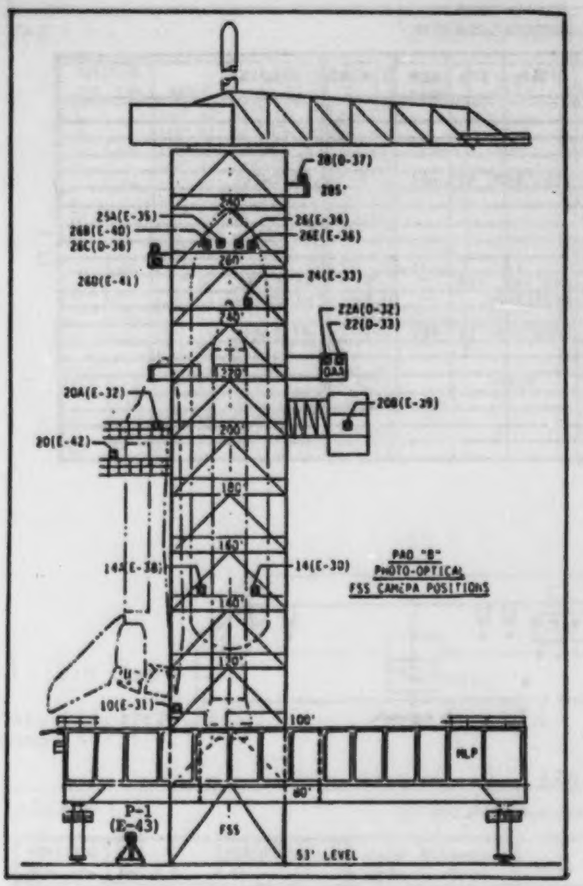


FIGURE 5

Location of Cameras on LC-39B Fixed Service Structure (51-L Configuration).

These instruments utilize 35mm or 70mm cameras coupled to lenses with focal lengths ranging from 100 to 500 inches. These lenses are auto-focus and temperature compensated. The locations of the cameras are shown in **figure 7**.

Coverage by these instruments is from first-acquisition until LOV. Two mounts are located north and two mounts south of the flight line at distances of 6 to 40 miles. Two of these mounts (one north, one south) track the Orbiter after SRB separation. The other two mounts track the SRBs after separation until LOV.

All of the above cameras are dedicated to viewing structural integrity, propulsion performance and possible flight anomalies of the launch vehicle during daylight hours (sunrise plus 45 minutes, sunset minus 45 minutes).

In the event of a launch being scheduled beyond this daylight period, exposure levels are adjusted to "flame exposure," thereby providing coverage of the propulsion plumes.

In addition, all tracking coverage is dependent upon weather conditions and cloud coverage at time of launch.

3. *Video System Description*

a. *Requirements*

The design criteria for the pad B MLP-2 and MLP-3 operational television (OTV) systems were defined by station set 81 and the pad A and MLP-1 OTV systems design. MLP-2 was to duplicate MLP-1, and MLP-3 was to duplicate MLP-2. The pad B OTV system was to duplicate the Pad A OTV system except for minor physical site differences.

b. *Definition of System*

The LC-39 OTV system provides visual observation of prelaunch and launch activities as seen by strategically located television cameras at pad A, pad B, the Orbiter processing facility, the Vehicle Assembly Building, and on the mobile launchers. These television cameras are equipped with pan-and-tilt units and with variable focal length zoom lenses (16mm to 320mm) that are remotely controlled via a digital control system from the LCC. The video signals are transmitted to the LCC over air dielectric coaxial cable with 10 television channels frequency-modulated (FM) and band-stacked (frequency division multiplexed) on each coaxial cable. At the LCC, these FM carriers (90 channels per pad) are demodulated and routed to a 192 x 512 video routing switcher for distribution to firing rooms and other user monitors. Selected television cameras are routed to a recording facility where 25 recorders/players record and play back in accordance with user needs. The OTV system consists of the following system/subsystems:

(1) Cameras
(2) Pan-and-tilt units
(3) Cabling system
(4) FM transmission system
(5) Switching system
(6) Monitoring system
(7) Digital control system
(8) Record system

c. *Capabilities*

The combined OTV subsystems provide the following capabilities:

(1) *Black-and-White TV Cameras*
Resolution: 750 TV lines
Sensitivity: Full output with scene illuminations from 20 foot-candles to full sunlight.
Standard: RS170 525-line interlaced scanning

(2) *Modulators/Demodulators (RF system)*
Modulation: Frequency modulation
Bandwidth: 6 MHz (450 lines TV resolution)

(3) *Video Distribution*
Bandwidth: 10 MHz (750 lines TV resolution)

(4) *User Monitors*
Resolution: 600 TV lines

(5) *Color TV Cameras*
Resolution: 300 TV lines
Sensitivity: Full output with scene illuminations from 20 foot-candles to full sunlight.
Standard: American "NTSC"

(6) *Recorders*
Resolution: 260 TV lines
Standard: 3/4-in. U-Matic

These OTV subsystems combined into a "system" providing TV coverage with a maximum of 450-TV-line resolution for pad black-and-white cameras and 280-TV-line resolution for Public Affairs Office (PAO) broadcast color TV cameras. This resolution is sufficient for broadcast and for day-to-day operational viewing; however, it falls far short of that required for detailed analysis in the event of a problem.

OTV camera placements are shown in **figures 8 through 12**. TV systems are also located in the Vehicle Assembly Building and in the Orbiter processing facility. Views are documented in OTV document KSCL-3420-021, Rev. 0, dated April 24, 1985.

FIGURE 6 Location of Cameras on MLP-2 (51-L Configuration).

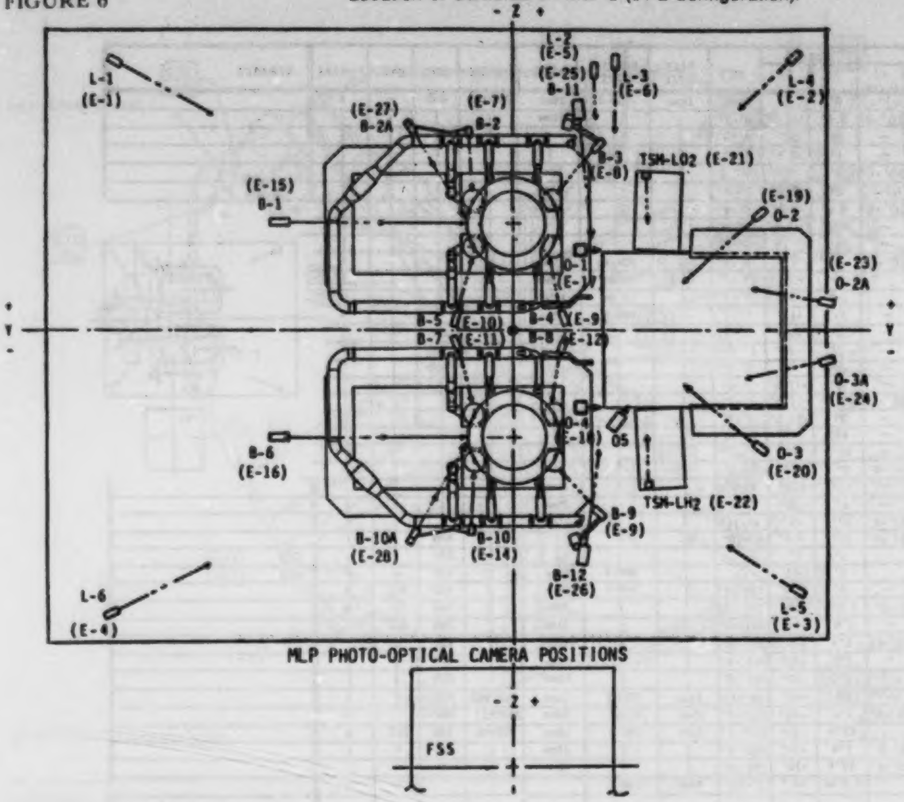
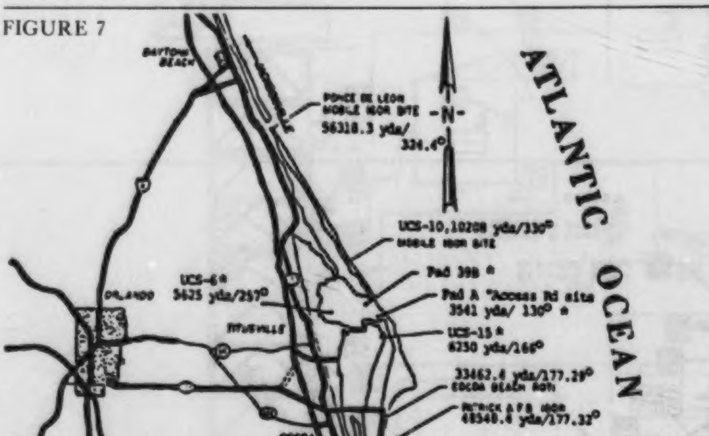

- Z +
L-1 (E-1)
L-2 (E-5)
(E-25) B-11
L-3 (E-6)
L-4 (E-2)
(E-27) B-2A
(E-7) B-2
B-3 (E-8)
TSM-LO2 (E-21)
(E-15) B-1
(E-19) O-2
O-1 (E-17)
(E-23) O-2A
+ Y -
B-5 (E-10)
B-4 (E-9)
B-7 (E-11)
B-8 (E-12)
O-3A (E-24)
O-4 (E-18)
O5
B-6 (E-16)
O-3 (E-20)
TSM-LH2 (E-22)
B-9 (E-9)
B-10A (E-28)
B-10 (E-14)
B-12 (E-26)
L-6 (E-4)
L-5 (E-3)
MLP PHOTO-OPTICAL CAMERA POSITIONS
- Z +
FSS

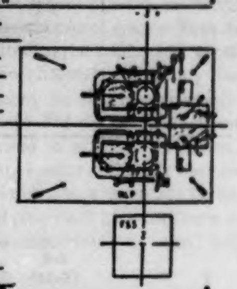
FIGURE 7


DAYTONA BEACH
PONCE DE LEON MOBILE IGOR SITE 56318.3 yds/ 334.4°
-N-
ATLANTIC OCEAN
UCS-10,10208 yds/330° MOBILE IGOR SITE
Pad 39B *
Pad A "Access Rd site 3541 yds/ 130° *
UCS-6* 3625 yds/257°
ORLANDO
TITUSVILLE
UCS-15 * 6250 yds/166°
33462.4 yds/177.29° COCOA BEACH ROTI
PATRICK A.F.B. IGOR 48540.4 yds/177.32°
COCOA
MELBOURNE
MELBOURNE BEACH ROTI 70427.5 yds/173.7°
*Distances at these sites are estimated.
TRACKING SITES as used for 51L Launch
Distance/Azimuth from Pad 39B

Tracking Camera Locations.

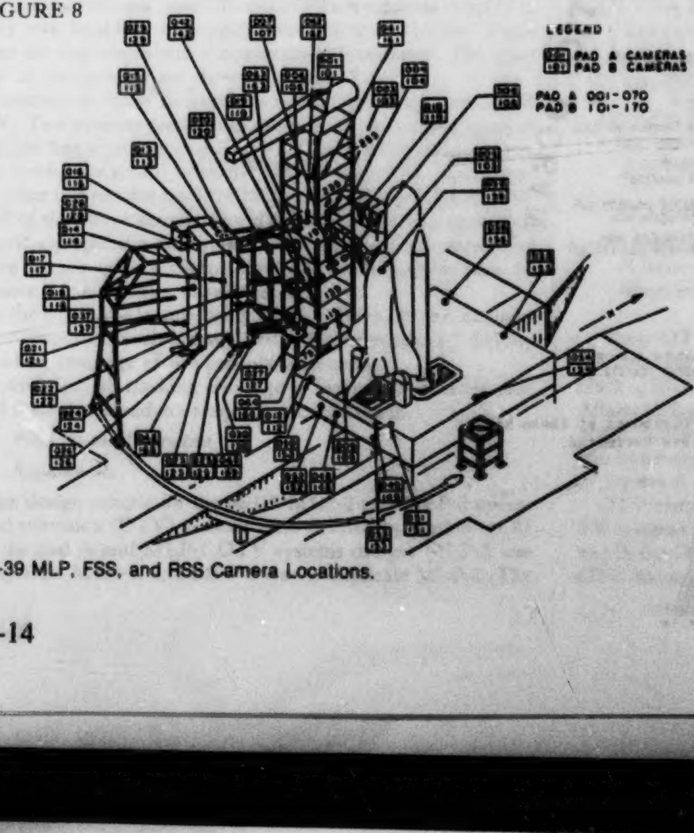
FIGURE 7

CAMERA	LOC	COORDINATES				ANGLES		HGT	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
		+Y	-Y	+Z	-Z	AZ	EL									
B1(E-15)	MLP	21'-0"	—	—	41'-7"	0°	0°	5'-6"	16mm	DBM-4	15mm	200'VNB	400	—	A	
B2(E-7)		37'-0"	—	—	10'-6"	7.5°	+11.5°	0'-9"			10mm					
B3(E-8)		37'-0"	—	10'-6"	—	36°	+8°	1'-8"								
B4(E-9)		5'-0"	—	9'-9"	—	9°	+3.5°	1'-8"								
B5(E-10)		5'-0"	—	—	10'-6"	6°	+8°	0'-10"			10mm					
B6(E-16)		—	21'-0"	—	41'-7"	0°	-5.5°	5'-4"			15mm					
B7(E-11)		—	5'-0"	—	10'-6"	8.5°	+4.5°	0'-9"			10mm					
B8(E-12)		—	5'-0"	9'-9"	—	9.5°	+4.5°	1'-8"								
B9(E-9)		—	37'-0"	9'-9"	—	38°	+7.5°	1'-9"								
B10(E-14)		—	37'-0"	—	10'-6"	17.5°	+9.5°	0'-9"		DBM-4	10mm				A	
B11(E-25)						26°	+19°	4'-3"		LOCAM	5.6mm				B	
B12(E-26)						15°	+22°	4'-3"		LOCAM	5.6mm				B	
L1(E-1)		62'-6"	—	36'-4"	—	25°	+12°	1'-9"		DBM-4	10mm				A	
L2(E-5)		59'-6"	—	11'-6"	—	3°	+20°	1'-9"			10mm		400			
L3(E-6)		60'-6"	—	16'-6"	—	7°	+30°	1'-10"			25mm		200			
L4(E-2)		67'-6"	—	53'-0"	—	42°	+9°	1'-6"			10mm		400			
L5(E-3)		—	57'-6"	53'-0"	—	52°	+12.5°	1'-6"								
L6(E-4)		—	62'-6"	—	86'-4"	22.5°	+12.5°	1'-7"								
O1(E-17)		16'-9"	—	34'-6"	—	0°	+53.5°	2'-4"								
O2(E-19)		21'-0"	—	45'-0"	—	45°	+30°	1'-10"								
O3(E-20)		—	21'-0"	45'-0"	—	48°	+26°	1'-11"								
O4(E-16)		—	16'-9"	—	14'-6"	0°	+55°	2'-5"								
O2A(E-23)		2'-10"	—	56'-4"	—	12°	+32°	2'-0"			25mm					
O3A(E-24)		—	2'-10"	56'-4"	—	6°	+30°	2'-1"			25mm					
B2A(E-27)		17'-7"	—	—	13'-6"	32°	-6°	4'-11"			15mm					
B10A(E-28)		—	17'-7"	—	13'-6"	32°	4.5°	4'-10"					400			
TSM (E-22)						7°	7°						200			LH2
TSM (E-21)						7°	7°			DBM-4	15mm		200	—	A	LO2
10(E-31)	FSS	—	76'-6"	19'-0"	—	0°	+25°	105'-4"		DBM-5	25mm		100	ALC	B	
14(E-38)		—	75'-10"	—	6'-0"	2.5°N	-28°	145'-6"			10mm		400	—	A	
20A(E-32)		—	72'-5"	27'-3"	—	1°N	-52°	204'-3"			25mm		200	ALC		
24(E-33)		—	75'-11"	—	11'-6"	1°S	-15°	245'-0"			100mm		400	—		
26(E-34)		—	75'-9"	3'-1"	—	2°S	-60°	264'-9"			15mm		400			
26A(E-35)		—	75'-8"			8°S	-12°	265'-0"			15mm		400			
26B(E-40)		—	75'-5"	3'-8"	—	0°	-62°	264'-10"	16mm	DBM-5	10mm	200'VNB	400		A	
26C(D-36)		—	73'-8"	—	25'-9"	1°N	-45°	265'-3"	35mm	NIKON	28mm	250WP53	N2		—	
26D(E-41)		—	75'-8"			12°N	-36°	262'-1"	16mm	DBM-5	10mm	200VNB	400	ALC	A	
26E(E-36)		—	76'-6"	—	6'-0"	2°N	+12°	265'-2"			15mm		400	—		
28(D-37)		—	74'-4"	—	29'-8"	12°N	+28°	291'-0"			10mm		48	—		
P1(E-43)	PAD					4.5°NE	+21°	3'-10"	16mm	DBM-5				—	A	



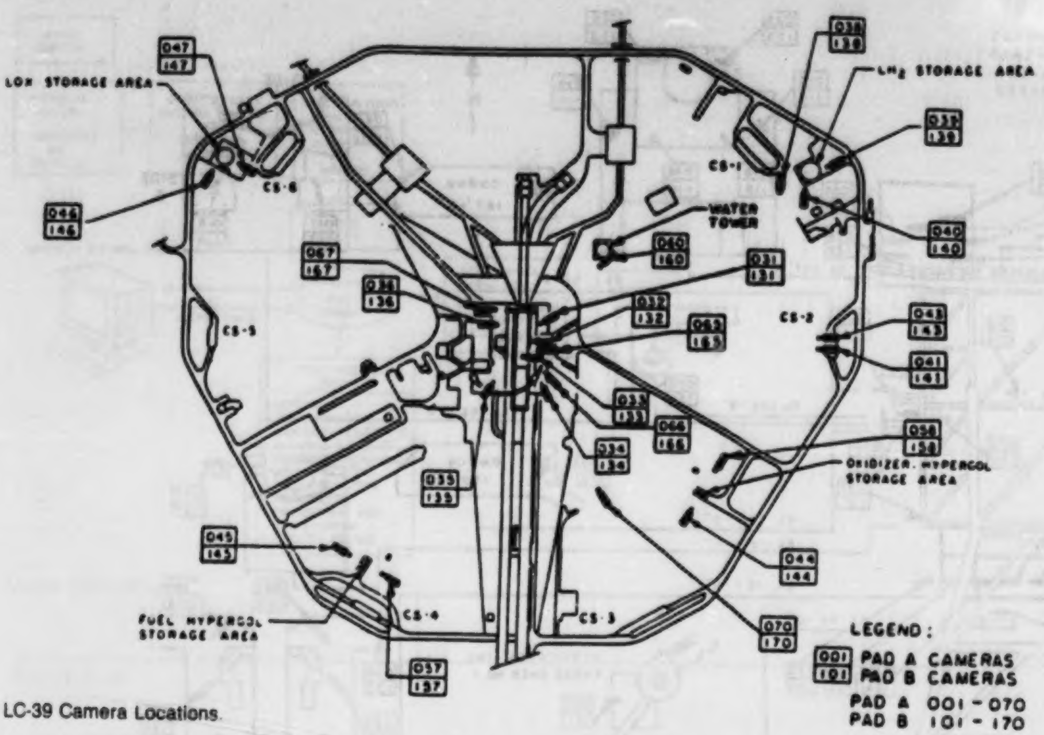
Viewing Angles and Coordinates of FSS and MLP-2 Cameras.

FIGURE 8



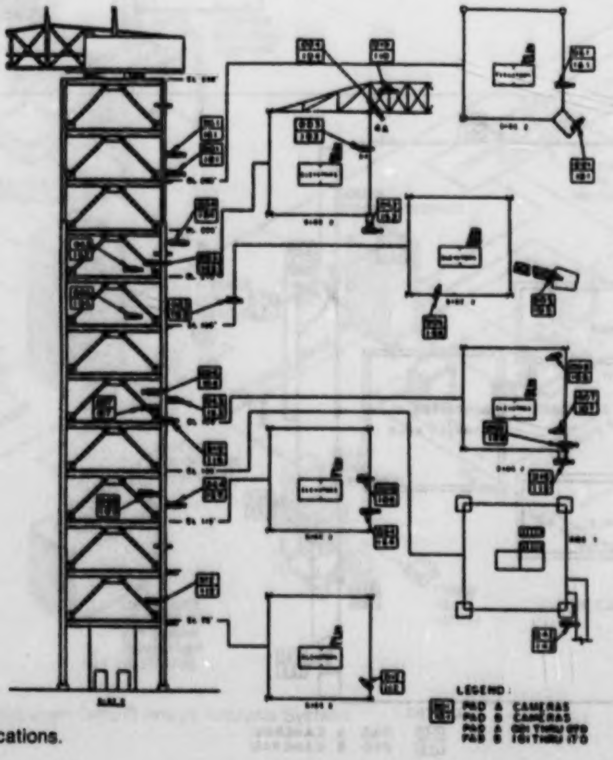
LC-39 MLP, FSS, and RSS Camera Locations.

FIGURE 9


047
147
LOX STORAGE AREA
046
146
CS-6
038
138
LH2 STORAGE AREA
039
139
CS-1
WATER TOWER
040
140
060
160
031
131
067
167
036
136
032
132
063
163
CS-2
043
143
041
141
CS-5
033
133
066
166
058
158
OXIDIZER. HYPERGOL STORAGE AREA
034
134
035
135
045
145
044
144
FUEL HYPERGOL STORAGE AREA
CS-4
CS-3
070
170
037
137
LEGEND:
001 PAD A CAMERAS
101 PAD B CAMERAS
PAD A 001 - 070
PAD B 101 - 170

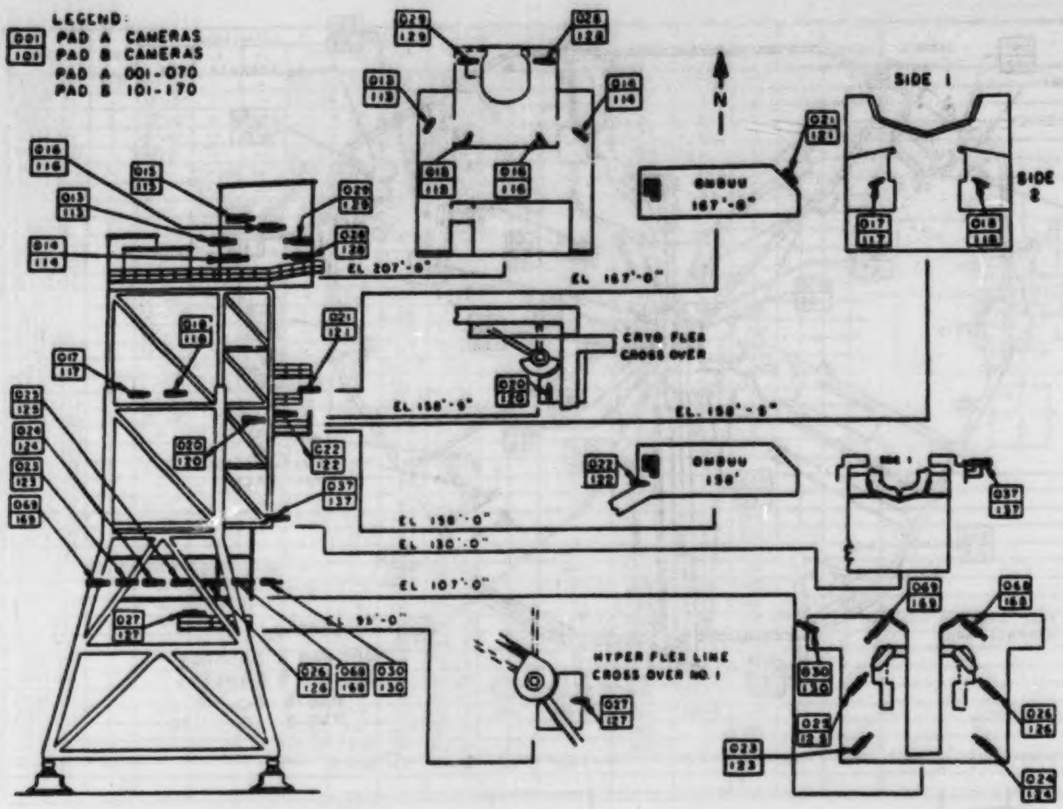
LC-39 Camera Locations.

FIGURE 10


LEGEND:
PAD A CAMERAS
PAD B CAMERAS
PAD A 001 THRU 070
PAD B 101 THRU 170

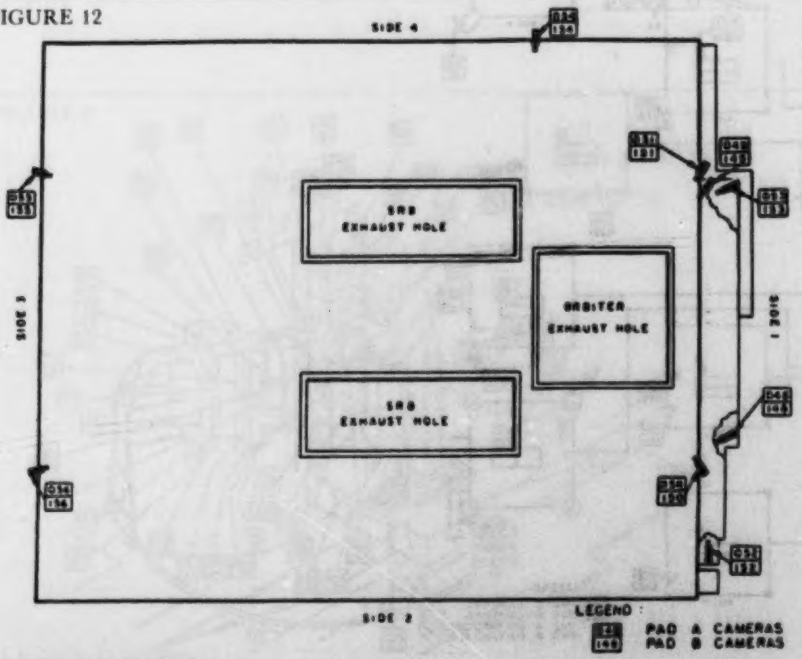
FSS Camera Locations.

FIGURE 11


LEGEND:
001 101
PAD A CAMERAS
PAD B CAMERAS
PAD A 001-070
PAD B 101-170
N
SIDE 1
SIDE 2
EL 207'-0"
EL 167'-0"
OMBUU 167'-0"
CRYO FLEX CROSS OVER
EL 158'-5"
EL. 158'-5"
OMBUU 138'
EL 138'-0"
EL 130'-0"
EL 107'-0"
EL 95'-0"
HYPER FLEX LINE CROSS OVER NO. 1
016 116
015 115
013 113
014 114
029 129
028 128
018 118
017 117
021 121
020 120
022 122
037 137
025 125
024 124
023 123
069 169
068 168
027 127
026 126
030 130

Rotary Service Structure Camera Locations.

FIGURE 12


SIDE 4
SIDE 3
SIDE 2
SIDE 1
SRB EXHAUST HOLE
SRB EXHAUST HOLE
ORBITER EXHAUST HOLE
034 134
032 132
LEGEND:
PAD A CAMERAS
PAD B CAMERAS

MLP Camera Locations.

FIGURE 13

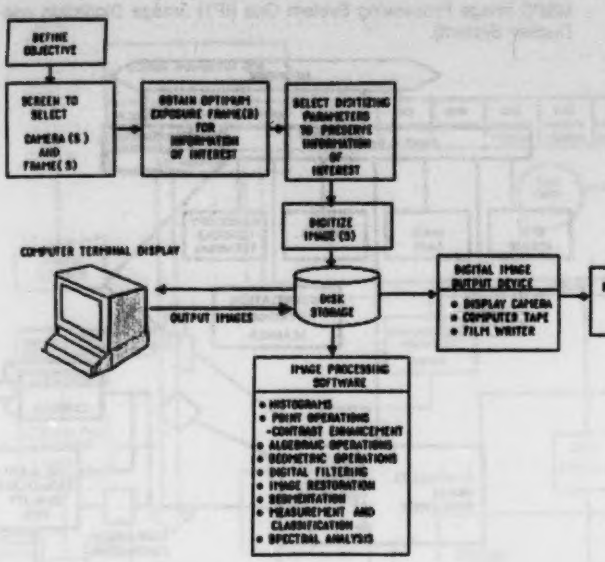
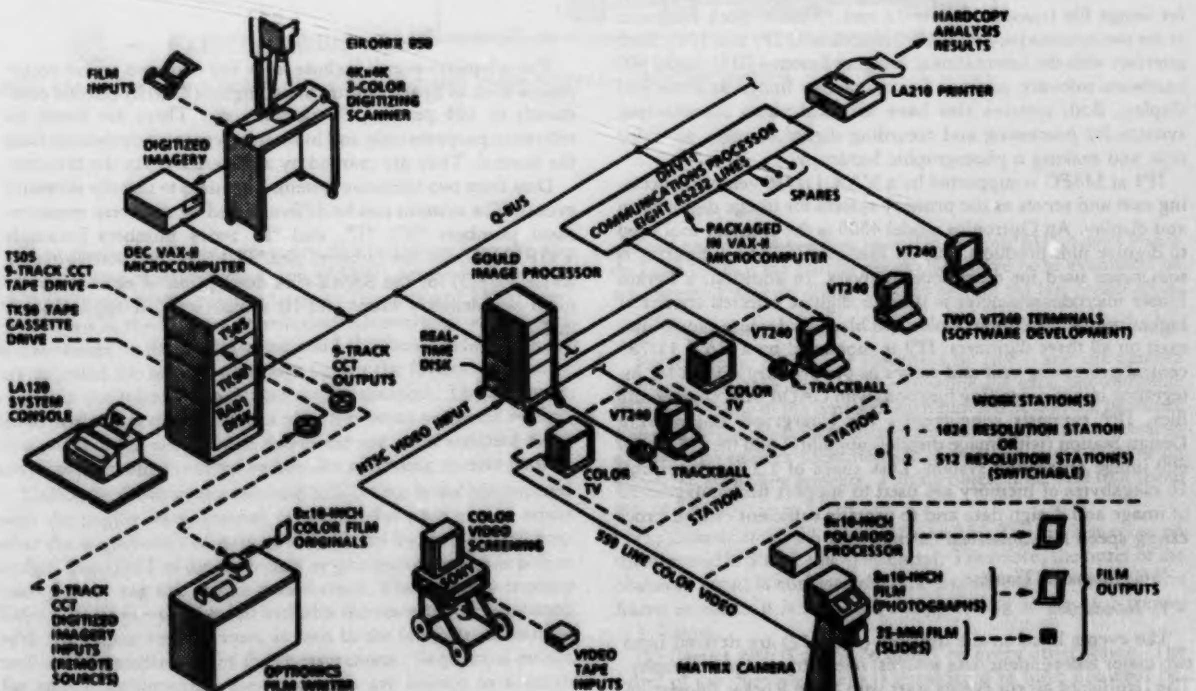

DEFINE OBJECTIVE
SCREEN TO SELECT CAMERA(S) AND FRAME(S)
OBTAIN OPTIMUM EXPOSURE FRAME(S) FOR INFORMATION OF INTEREST
SELECT DIGITIZING PARAMETERS TO PRESERVE INFORMATION OF INTEREST
DIGITIZE IMAGE(S)
COMPUTER TERMINAL DISPLAY
OUTPUT IMAGES
DISK STORAGE
DIGITAL IMAGE OUTPUT DEVICE
• DISPLAY CAMERA
• COMPUTER TAPE
• FILM WRITER
PROCESSED IMAGE
IMAGE PROCESSING SOFTWARE
• HISTOGRAMS
• POINT OPERATIONS
-CONTRAST ENHANCEMENT
• ALGEBRAIC OPERATIONS
• GEOMETRIC OPERATIONS
• DIGITAL FILTERING
• IMAGE RESTORATION
• SEGMENTATION
• MEASUREMENT AND CLASSIFICATION
• SPECTRAL ANALYSIS

Image Processing.

FIGURE 14


EIKONIX 850
4Kx4K 3-COLOR DIGITIZING SCANNER
FILM INPUTS
DIGITIZED IMAGERY
HARDCOPY ANALYSIS RESULTS
LA210 PRINTER
DHV11 COMMUNICATIONS PROCESSOR EIGHT RS232 LINES
SPARES
PACKAGED IN VAX-II MICROCOMPUTER
Q-BUS
DEC VAX-II MICROCOMPUTER
TS05 9-TRACK CCT TAPE DRIVE
TK50 TAPE CASSETTE DRIVE
TS05
TK50
RA81 DISK
LA120 SYSTEM CONSOLE
9-TRACK CCT OUTPUTS
GOULD IMAGE PROCESSOR
REAL-TIME DISK
VT240
VT240
TWO VT240 TERMINALS (SOFTWARE DEVELOPMENT)
VT240
TRACKBALL
COLOR TV
VT240
TRACKBALL
COLOR TV
STATION 2
STATION 1
WORK STATION(S)
1 - 1024 RESOLUTION STATION
OR
2 - 512 RESOLUTION STATION(S) (SWITCHABLE)
NTSC VIDEO INPUT
8x10-INCH COLOR FILM ORIGINALS
COLOR VIDEO SCREENING
SONY
525 LINE COLOR VIDEO
8x10-INCH POLAROID PROCESSOR
8x10-INCH FILM (PHOTOGRAPHS)
35-MM FILM (SLIDES)
FILM OUTPUTS
MATRIX CAMERA
VIDEO TAPE INPUTS
9-TRACK CCT DIGITIZED IMAGERY INPUTS (REMOTE SOURCES)
OPTRONICS FILM WRITER (AT LUNAR PLANETARY INSTITUTE)

Visual Analysis Subteam (VAST) Image Analysis System.

4. *Enhancement Systems*

In addition to the usual viewing equipment such as light tables and projectors, digital image processing systems were employed on selected image frames by JSC, MSFC, and several government and industry organizations. Such systems provide image digitization, image data management, image mensuration, integrated computer-aided-design (CAD) and image processing of various types, and image display including color photography and animation on video tape. Each selected frame was appropriately processed to enhance or measure features of interest, with specific analysis techniques selected from general capabilities such as are indicated in *figure 13*. An overview of the JSC and MSFC digital image processing system hardware and software is given. The other government and industry organizations employed in enhancement and analysis also are listed in Section V.D.8.

The JSC digital image processing system is represented by the diagram in *figure 14*. An Eikonix model 850 linear array film digitizer with color and black-and-white capabilities was used. A Gould IP 8500 color image display and real-time disk allows evaluation of image quality, provides image data management, and supports image analysis through two image terminals accessing a modified Library of Image Processing Subroutines (LIPS). This system also provides video digitizing. A DEC Microvax II processor is the host computer system. Disk space of 786 megabytes and 9 megabytes of memory are available as well as a DECNET network interface. CAD manipulation capability allows measurement of size, location, shape, relative motion, and other features. Three engineering CAD systems were employed at JSC to generate automatically views of the stack from the camera's viewpoint. The JSC image processing system has both video and photo outputs.

MSFC used two networked image processing systems in parallel for image file transfer. *Figures 15* and *16* show block diagrams of the two systems (subsequently referred to as IP1 and IP2). Both interface with the International Imaging Systems (IIS) model 600 hardware/software package for interactive image analysis and display. Both systems also have identical video input/output systems for processing and recording digital imagery on video tape and making a photographic hardcopy.

IP1 at MSFC is supported by a VAX 11/730 central Processing unit and serves as the primary system for image digitization and display. An Optronics model 4500 is the primary tool used to digitize film products, but an Eikonix CCD film digitizer is sometimes used for quick-look analyses. In addition, a Perkin Elmer microdensitometer is used to digitize selected frames at higher spatial resolution. Color and black-and-white capabilities exist on all three digitizers. IP2 is supported by a VAX 11/785 central processing unit and serves as the primary system for integrating image processing functions with CAD/CAM engineering files. IP2 supports concurrently the Intergraph Engineering Design Station (with image display capability) and the IIS model 600 image processing system. Disk space of 1.2 gigabytes and 16 megabytes of memory are used to support file management of image and design data and to provide sufficient central processing speed for numerical calculations.

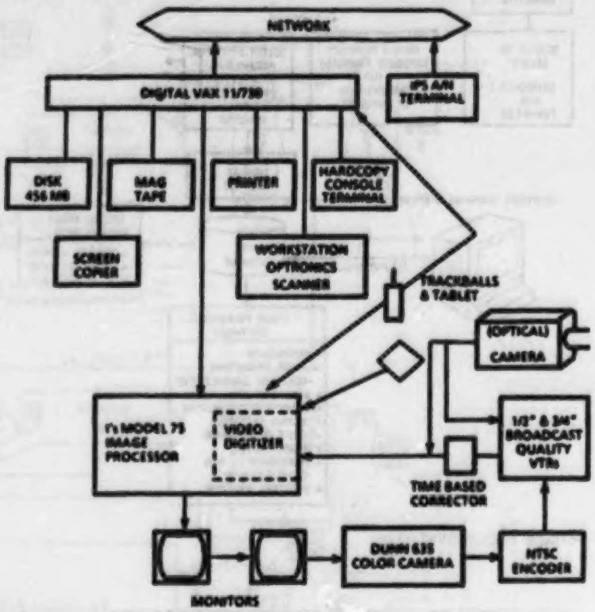
V.C. *Integrated Timeline*

1. *Introduction*

The events listed in the timeline (*figure 17*) are derived from two major independent data sources: telemetry and photography. The significant ascent events start with Solid Rocket Booster ignition and end with SRB destruct. A common vehicle coordinate system used for both photographic and telemetry events is shown in *figure 18*. Event times listed in this report are given in mission elapsed time, with SRB ignition defined at 028:16:38:00.010 Greenwich mean time (GMT).

FIGURE 15

MSPC Image Processing System One (IP1) (Image Digitation and Display System).

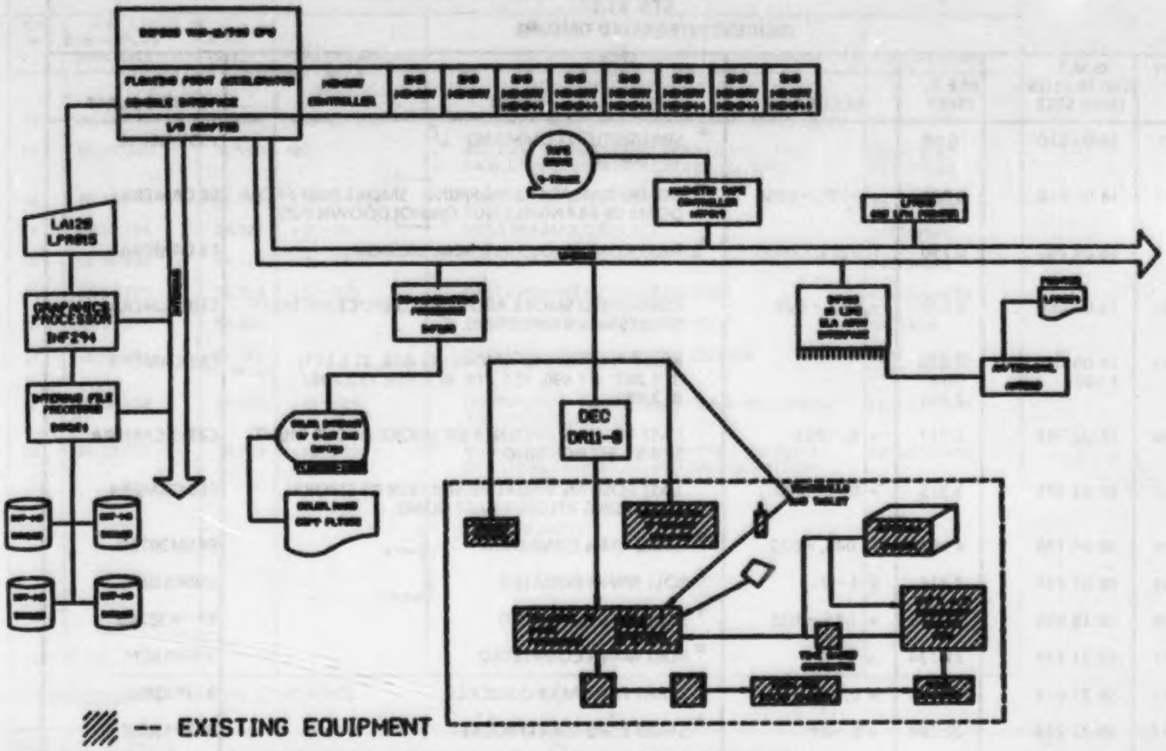


a. *Telemetry Events*

The telemetry events include some key expected ascent occurrences such as Space Shuttle main engine (SSME) throttle commands to 104 percent, 94 percent, etc. These are listed for reference purposes only and in no way represent deviations from the normal. They are marked by an asterisk (*) in the timeline.

Data from two telemetry systems were used to identify telemetry events. The systems can be differentiated by the event measurement numbers "V", "T", and "B" series numbers (example V41P1300C) for the Orbiter, and "E" series numbers (example E41M3076D) for the SSME's. A description of each measurement or telemetry event and its sample rate, if applicable, is included.

FIGURE 16



MSFC Image Processing System Two (IP2) (Integrated Image Analysis—CAD/CAM System).

Time applied to Orbiter telemetry data is derived from the onboard Orbiter master timing unit (MTU) time which is synchronized with GMT prior to launch. The onboard MTU time is included in the Orbiter downlinked telemetry bit stream and is downlinked at 10 samples/second with the data. The event times are adjusted for all known delays within the Orbiter telemetry to within the tolerance indicated on the timeline. The tolerance listed with each time indicates that the event occurred as first observed by this sample, but due to the nature of sampled data, may have actually occurred within one preceding sample period.

Unlike the Orbiter, the onboard MTU time is not telemetered with the engine data. Instead, a counter for each engine resets after the engine start command is validated by each engine controller. The GMT of the individual engine start commands is then used to time tag the engine data frames. The time uncertainty listed with each engine event includes the uncertainty associated with the engine counter reset as seen in the telemetered data as well as the sample rate of the measurement. Sequential events for engine performance measurements are known to a much greater accuracy.

All times are listed in both GMT and MET which is referenced to T-0 as identified by the SRB ignition command.

The raw data source for all the telemetry vents is either the Space Shuttle main engine 60-kilobit (kb) data from each engine or the Orbiter downlinked 192-kb bitstream (128-kb data + 64-kb voice) as recorded at the Merritt Island Launch Area (MILA) ground station. Data tapes recorded at both MILA and Ponce de Leon (PDL), the official range sites, have been examined on a telemetry frame-by-frame basis to extract the last usable data.

b. *Photographic Events*

Photographic events are identified by MET and the camera number. The time listed in the timeline for each photographic event is the time of the center of each film frame and the tolerance is derived from the camera frame rate. All launch film was reviewed, and the camera identified for each event is the camera on which the event first appears. Timing notes, time, and film speed are as follows:

(1) *Cameras 202, 204, 206, 207, and 216*: Timing is marked on the film and is film-frame referenced. Therefore, the onset of the observed event is considered to have occurred between the first frame in which it is seen and the preceding frame (+0 frame, −1 frame).

(2) *Camera 230*: Time is recorded on every other frame. The onset of the observed event is considered to have occurred between the frame in which it is first seen and the previous frame.

(3) *Camera 203*: Film does not have a time frame reference recorded and therefore results in an uncertainty of plus or minus one-half frame. The onset of the observed event is considered to have occurred between the frame in which it is first seen and the preceding frame (+0 frame, −1 frame), for a total inaccuracy of + ½ frame, −1½ frames.

FIGURE 17 PG 1

STS 51-L INCIDENT INTEGRATED TIMELINE					
EVT. #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
01	38:00.010	0.00		* SRB IGNITION COMMAND V90W8380C	V99W8801C
02	38:00.018	0.008	+ .0025, - .0050	* HOLDDOWN POST 2 PIC FIRING - SMOKE PUFF FROM DOME OF FRANGIBLE NUT ON HOLDDOWN POST	E8 CAMERA
03	38:00.260	0.250	+ .0025, - .0050	* FIRST CONTINUOUS VERTICAL MOTION	E9 CAMERA
04	38:00.688	0.678	+ .010, - .020	CONFIRMED SMOKE ABOVE FIELD SPLICE INITIALLY MOVES IN + X DIRECTION.	E60 CAMERA
05	38:00:846 thru 2.509	0.836 thru 2.499		MULTIPLE PUFFS OF SMOKE: 1) .836; 2) 1.171; 3) 1.283; 4)1.496; 5) 1.779; 6) 2.185; 7) 2.296; 8) 2.499	E63 CAMERA
06	38:02.743	2.733	+ .0, -.033	LAST POSITIVE EVIDENCE OF SMOKE ABOVE RIGHT SRB/ET ATTACH RING.	CZR-1 CAMERA
07	38:03.385	3.375	+ .010, -.020	LAST POSITIVE VISUAL INDICATION OF SMOKE DISPERSING BELOW ET AFT DOME.	E60 CAMERA
08	38:04.374	4.364	+ .045, -.035	* SSME 104% COMMAND	E41M3076D
09	38:07.734	7.724	+ 0,-.2	* ROLL MNVR INITIATED	V90R5301C
10	38:19.895	19.885	+ .045, -.035	* SSME 94% COMMAND	E41M3076D
11	38:21.134	21.124	+ 0,-.2	* ROLL MNVR COMPLETED	V90R5301C
12	38:21.614	21.604	+ 0,-.08	* START R SRB MAX Q BUCKET	B47P2302C
13	38:22.214	22.204	+0, -.08	* START L SRB MAX Q BUCKET	B47P1302C
				* EXPECTED EVENT	

Incident Integrated Timeline.

(4) *Cameras E8, E9, E60 and E63*: Film does not have a time frame reference recorded and therefore results in an uncertainty of plus or minus one frame. The onset of the observed event is considered to have occurred between the first frame in which it was seen and the preceding frame (+ 0 frame, - 1 frame), for a total inaccuracy of + 1 frame, - 2 frames.

(5) *Camera CZR-1*: Camera CZR-1 time is marked on the film. Therefore, the onset of the observed event is considered to have occurred between the first frame in which it is seen and the preceding frame (+ 0 frame, - 1 frame).

(6) *Camera D67*: Film is not time-coded, and film frame rate is variable between 4 to 5.5 frames/second. The camera also skews its look angle upward after lift-off. Time estimates have been made utilizing the launch tower as a reference for measuring T-0.

(7) *Film Speed and Accuracy*: The film speed and accuracy are shown in the following table:

Camera	*Frame Rate*	*Accuracy*
E8 – 16mm	400 frames/sec	+ 0.0025, - 0.0050
E9 – 16mm	400 frames/sec	+ 0.0025, - 0.0050
E60 – 16mm	100 frames/sec	+ 0.010, - 0.020
E63 – 16mm	100 frames/sec	+ 0.010, - 0.020
E202 – 70mm	30 frames/sec	+ 0.0, - 0.033
E203 – 80mm	30 frames/sec	+ 0.16, - 0.049
E204 – 35mm	45 frames/sec	+ 0.0, - 0.022
E206 – 70mm	40 frames/sec	+ 0.0, - 0.025
E207 – 70mm	40 frames/sec	+ 0.0, - 0.025
E216 – 16mm	48 frames/sec	+ 0.020, - 0.040
E230 – 35mm	70 frames/sec	+ 0.0, - 0.014
CZR-1 – 140mm	30 frames/sec	+ 0.0, - 0.033
D67 – 35mm	4 to 5.5 frames/sec	Not applicable

FIGURE 17 PG 2

STS 51-L
INCIDENT INTEGRATED TIMELINE

EVT. #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
14	38:35.416	35.406	+ .045, -.035	* SSME 65% COMMAND TVC - COMMAND RESPONSE	E41M3076D
15	38:37:000	36.990	N/A	* INTERVAL OF 38:37:00 TO 39:03:00 ROLL AND YAW ATTITUDE ERROR RESPONSE TO WIND.	V95H3522C V95H3523C
16	38:51.896	51.886	+ .045, -.035	* SSME 104% COMMAND	E41M3076D
17	38:54.134	54.124	+ 0, -.08	* END L SRB MAX Q BUCKET	B47P1302C
18	38:54.334	54.324	+ 0, -.08	* END R SRB MAX Q BUCKET	B47P2302C
19	38:58.798	58.788	+ 0, -.025	FIRST EVIDENCE OF FLAME ON R SRB	E207 CAMERA
20	38:59.010	59.000		* RECONSTRUCTED MAX Q 720 PSF	JSC DATA
21	38:59:772	58.762 to 59.26		FLICKERING DYNAMIC PLUME ON RSRB	E207 CAMERA (ENHANCED)
22	38:59.272	59.262	+ 0, -.025	CONTINUOUS WELL-DEFINED PLUME ON R SRB IN + Z, -Y COORDINATES.	E207 CAMERA
23	38:59.763	59.753	+ 0, -.022	VISUAL EVIDENCE OF FLAME FROM R SRB IN + Z DIRECTION, NEAR ET ATTACH RING (SEEN FROM SOUTH SIDE).	E204 CAMERA
				* EXPECTED EVENT	

Incident Integrated Timeline (Continued).

FIGURE 17 PG 3

STS 51-L
INCIDENT INTEGRATED TIMELINE

EVT. #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
24	39:00.014	60.004	+ 0, -.08	SRB CHAMBER PRESS DIVERGENCE RH vs LH	B47P2302C RIGHT B47P1302C LEFT
25	39:00:248	60.238	+ 0, -.025	FIRST EVIDENCE OF PLUME DEFLECTION - INTERMITTANT	E207 CAMERA
26	39:00.258	60.248	+ .016, -.049	FIRST EVIDENCE OF ANOMALOUS SRB PLUME ATTACHING TO THE ET 2058 RING FRAME.	E203 CAMERA
27	39:00:998	60.988	+ 0, -.025	FIRST EVIDENCE OF PLUME DEFLECTION CONTINUOUS	E207 CAMERA
28	39:02.104	62.094	+ 0, -.040	START L SRB TVC ROCK ACT SPIKE	B58H1150C
29	39:02.494	62.484	+ 0, -.08	RHOB ELEV ACT HINGE MOMENT SPIKE	V58P0966C
30	39:03.934	63.924	+ 0, -.08	RHOB ELEVON ACTUATOR DELTA P CHANGE	V58P0966C
31	39:04.614	64.604	+ 0, -.2	START VEHICLE PITCH RATE CHANGE	V90R2525C LEFT
32	39:04.670	64.660	+ 0, -.022	ABRUPT CHANGE IN ANOMALOUS PLUME SHAPE, FIRST INDICATION OF LH_2 LEAK NEAR ET 2058 RING FRAME.	E204 CAMERA
33	39:04.715	64.705	+ 0, -.022	BRIGHT SUSTAINED GLOW ON + Z & -Z SIDES OF E.T.	E204 CAMERA
34	39:04.947	64.937	+ 0, -.04	START ME LARGE PITCH VARIATIONS	V58H1100A
35	39:05.414	65.404	+ 0, -.2	END VEHICLE PITCH RATE CHANGE	V90R2525C LEFT
36	39:05.534	65.524	+ 0, -.08	LHOB ELEVON ACTUATOR DELTA P CHANGE	V58P0866C
37	39:06.774	66.764	+ 0, -.2	START ET LH_2 ULLAGE PRESSURE DEVIATIONS	T41P1706C
38	39:12.211	72.201	+ 0, -.2	START DIVERGENT -YAW RATES R vs L SRB	V90R2528C RIGHT V90R2526C LEFT
				* EXPECTED EVENT	

Incident Integrated Timeline (Continued).

FIGURE 17 PG 4

STS 51-L
INCIDENT INTEGRATED TIMELINE

EVT #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
39	39:12.291	72.281	+0, -.2	START DIVERGENT + PITCH RATES R vs L SRB	V90R2527C RIGHT V90R2525C LEFT
40	39:12.486	72.476	+0, -.04	SRB MAJOR III RATE ACTUATOR CMD	V79H2111A
41	39:12.507	72.497	+0, -.04	ME PITCH/ROLL GIMBAL RATE (5°/SEC)	V58H1100A
42	39:12.525	72.515	+0, -.04	VEH MAX LATERAL + Y ACCEL 0.227G	V98A1581C
43	39:12.574	72.564	+0, -.2	START OF LH_2 TANK PRESS DECREASE WITH TWO FLOW CONTROL VALVES OPEN	T41P1700C
44	39:12.574	72.564	+0, -.04	SRB MAJOR III RATE ACTUATOR MOTION	B58H1151C
45	39:12.634	72.624	+0, -1	* LAST STATE VECTOR DOWN LINKED	V95L0190C
46	39:12.974	72.964	+0, -.08	START OF SHARP MPS LO_2 INLET PRESSURE DROP	V41P1130C
47	39:13.020	73.010		ORBITER & TDRS RATE COMPARE AT LAST TDRS DATA	
48	39:13.054	73.044	+0, -.08	R SRB CHAMBER PRESS 24 PSI (APPROX. 6 SIGMA) LOWER THAN L SRB	B47P2302C RIGHT B47P1302C LEFT
49	39:13.065	73.055	+0, -.04	VEH MAX LATERAL -Y ACCEL, 0.254 G	V98A1581C
50	39:13.134	73.124	+0, -.022	EVIDENCE OF CIRCUMFERENTIAL WHITE PATTERN ON LEFT SIDE OF ET AFT DOME (LH_2 TANK FAILURE NEAR 2058 RING FRAME).	E204 CAMERA
51	39:13.147	73.137	+0, -.025	FIRST HINT OF VAPOR AT INTERTANK STAGE	E207 CAMERA
				* EXPECTED EVENT	

Incident Integrated Timeline (Continued).

FIGURE 17 PG 5

STS 51-L
INCIDENT INTEGRATED TIMELINE

EVT #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
52	39:13.169	73.159	+.045, -.035	ME'S RESPONDING TO LOSS OF FUEL AND OXID INLET PRESS	E41P3016D
53	39:13.172	73.162	+0, -.025	SUDDEN CLOUD ALONG SIDE OF ET BETWEEN INNER TANK AND AFT DOME	E207 CAMERA
54	39:13.201	73.191	+0, -.022	FLASH FROM REGION BETWEEN ORBITER AND ET LH_2 TANK	E204 CAMERA
55	39:13.223	73.213	+0, -.022	FLASH NEAR SRB FWD ATTACH (INTERTANK) AND BRIGHTENING OF FLASH BETWEEN ORBITER AND ET	E204 CAMERA
56	39:13.292	73.282	+0., -.022	FIRST INDICATION INTENSE WHITE FLASH AT SRB FWD ATTACH POINT	E204 CAMERA
57	39:13.337	73.327	+0, -.022	GREATLY INCREASED INTENSITY OF WHITE FLASH	E204 CAMERA
58	39:13.387	73.377	+0, -.04	START RCS JET CHAMBER PRESS FLUCTUATIONS	V42P1552A
59	39:13.409	73.399	+.045, -.035	ME'S APPROACHING HPFT DISCH TEMP REDLINE	E41T2010D
60	39:13.553	73.543	+.045, -.035	ME 1 IN SHUTDOWN HPFT DISCH TEMP IN REDLINE EXCEEDED	E41J1512B
				LAST VALIDATED TELEMETRY MEASUREMENTS	
61	39:13.625	73.615	+0, -.04	L3L RCS JET CHAMBER PRESS	V42P2545A
62	39:13.628	73.618	+0, -.01	APU 1 GAS GENERATOR CHAMBER PRESS	V46P0120A
63	39:13.641	73.631	+.0005, -.0005	END OF LAST DATA FRAME WITH VALID SYNC AND FRAME COUNT	RAW DATA DUMP
				* EXPECTED EVENT	

PC 110788

Incident Integrated Timeline (Continued).

FIGURE 17 PG 6

STS 51-L
INCIDENT INTEGRATED TIMELINE

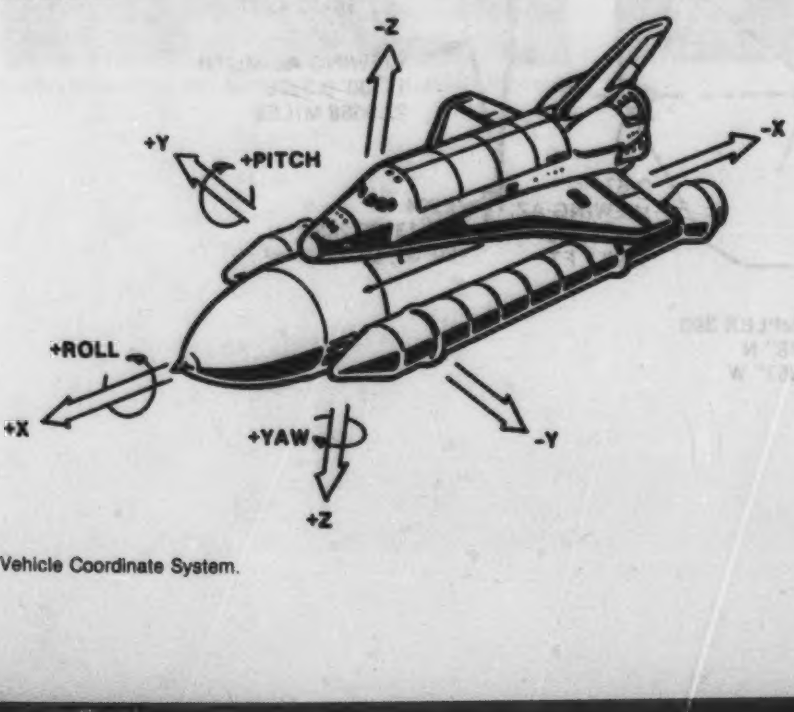
EVT. #	G.M.T. 028:16:PLUS (MIN:SEC)	M.E.T. (SEC)	ACCURACY	EVENT	DATA SOURCE
64	39:14.140	74.130	+.002, −.002	LAST RF SIGNAL FROM ORBITER	GROUND VIDEO & RECEIVER AGC
65	39:14.597	74.587	+0, −.022	BRIGHT FLASH IN VICINITY OF ORBITER NOSE	E204 CAMERA
66	39:16.447	76.437	+0, −.025	R SRB NOSE CAP SEP/CHUTE DEPLOYMENT	E207 CAMERA
67	39:50.260	110.250	+0, −.033	R SRB RSS DESTRUCT	E202 CAMERA
68	39:50.262	110.252	+0, −.014	L SRB RSS DESTRUCT	E230 CAMERA

NOTES:

1. ADD 0.010 TO MET TO OBTAIN G.M.T.
2. * INDICATES EVENTS ARE EXPECTED AND INCLUDED FOR REFERENCE ONLY
3. REVIEW OF TDRS / IUS PDI DATA SHOWED NO ANOMALOUS CONDITIONS

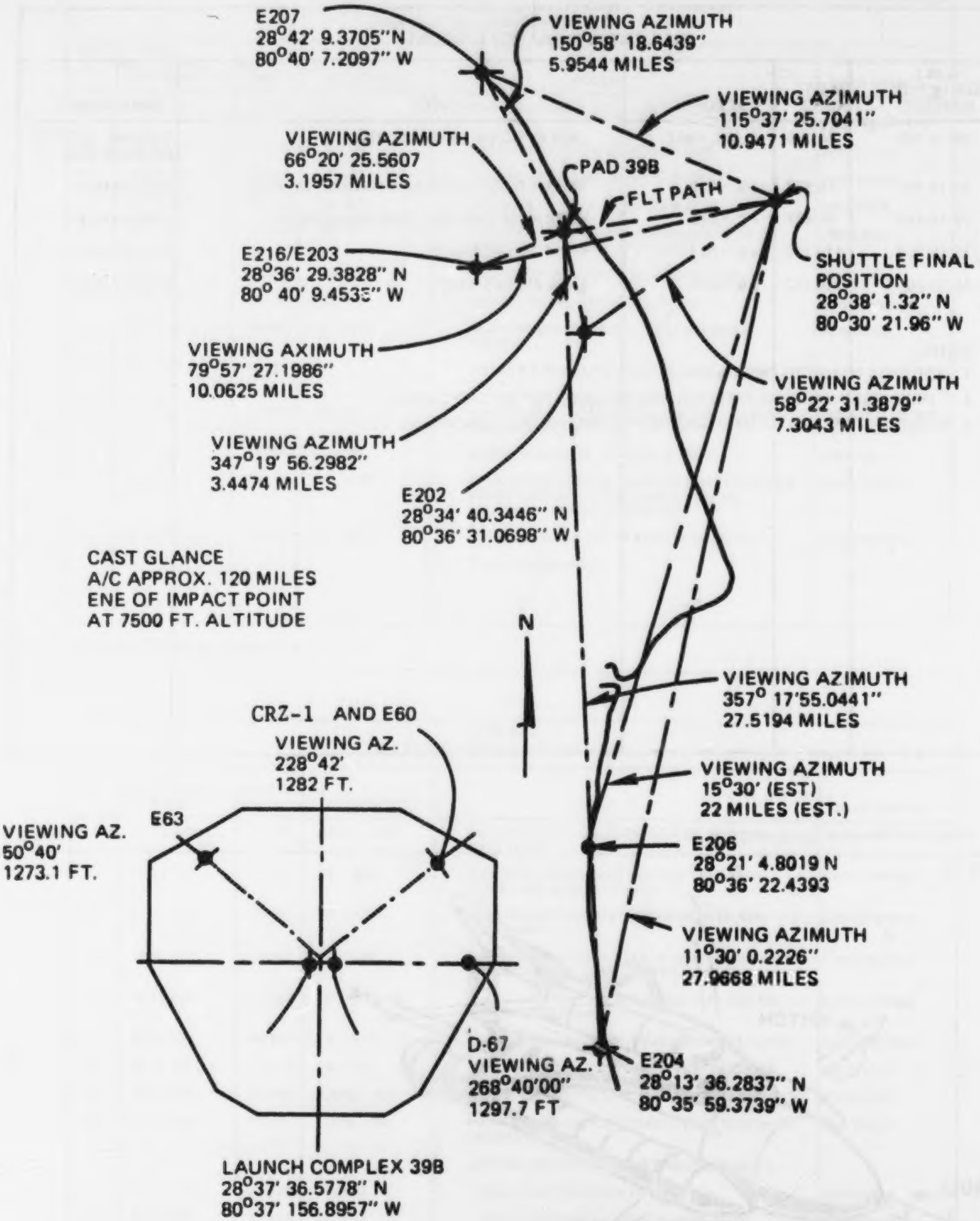
Incident Integrated Timeline (Continued).

FIGURE 18



Vehicle Coordinate System.

FIGURE 19


E207
28°42' 9.3705"N
80°40' 7.2097" W
VIEWING AZIMUTH
150°58' 18.6439"
5.9544 MILES
VIEWING AZIMUTH
115°37' 25.7041"
10.9471 MILES
VIEWING AZIMUTH
66°20' 25.5607
3.1957 MILES
PAD 39B
FLT PATH
E216/E203
28°36' 29.3828" N
80° 40' 9.4533" W
SHUTTLE FINAL
POSITION
28°38' 1.32" N
80°30' 21.96" W
VIEWING AXIMUTH
79°57' 27.1986"
10.0625 MILES
VIEWING AZIMUTH
58°22' 31.3879"
7.3043 MILES
VIEWING AZIMUTH
347°19' 56.2982"
3.4474 MILES
E202
28°34' 40.3446" N
80°36' 31.0698" W
CAST GLANCE
A/C APPROX. 120 MILES
ENE OF IMPACT POINT
AT 7500 FT. ALTITUDE
N
VIEWING AZIMUTH
357° 17'55.0441"
27.5194 MILES
CRZ-1 AND E60
VIEWING AZ.
228°42'
1282 FT.
VIEWING AZIMUTH
15°30' (EST)
22 MILES (EST.)
VIEWING AZ.
50°40'
1273.1 FT.
E63
E206
28°21' 4.8019 N
80°36' 22.4393
VIEWING AZIMUTH
11°30' 0.2226"
27.9668 MILES
D-67
VIEWING AZ.
268°40'00"
1297.7 FT
E204
28°13' 36.2837" N
80°35' 59.3739" W
LAUNCH COMPLEX 39B
28°37' 36.5778" N
80°37' 156.8957" W

Camera Locations and Look angles.

The location of the cameras and their look angles is specified in *figure 19*.

2. *Events*

Each event listed in *figure 17* is shown with the data and/or photography which describes the event. The event numbers correspond to the numbers shown in *figure 17*.

(1) *Calculation of SSME and SRB Ignition Times*

Mission elapsed time: T-0

The SSME and SRB ignition signals are a result of software flags which are generated in the redundant set launch sequencer (RSLS). For the SSME's, the flag is interpreted by the SSME software operation program (SOP) and sent to the engine interface unit (EIU). For the SRB's, the flag is interpreted by the master events controller (MEC) SOP and sent to the SRB ignition pyrotechnics. All of the times are referenced from an expected time of lift-off (GMTLO, V99W8801C) that was sent from the launch processing system to the RSLS. The RSLS subtracts the GMTLO value from its current value for GMT; this difference is the high-frequency executive read of GMT completed 54 milliseconds prior to the start of the 40-millisecond cycle in which the RSLS is running and checks to see if the difference is less than 6.600 seconds. On the first pass that the criteria is satisfied, the software flag for main engine 3 start command is set. The calculation of this difference is not made again, and the last value is held in the telemetry stream (V90W8380C). The timing is such that 6.600 seconds after this time, the software flag is set by the RSLS for the MEC SOP to fire the SRB ignition pyrotechnics.

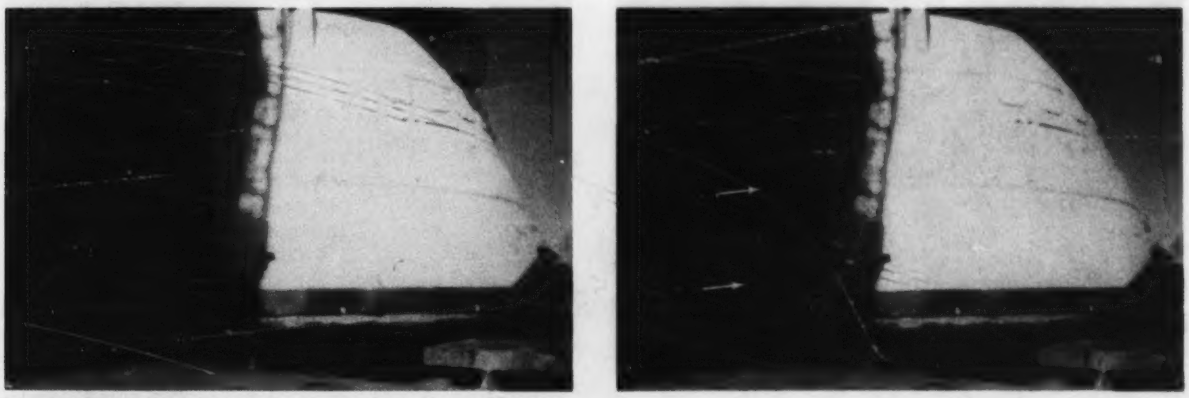
Forty milliseconds after setting the software flag for SRB ignition, the RSLS logic sets a flag for T-0 umbilical-release fire commands. The MEC SOP translates this into a command to the MEC for T-0 umbilical release. The MEC splits this input into T-0 umbilical release and holddown-bolt pyrotechnics fire commands which leave the MEC 40 milliseconds after the SRB ignition pyrotechnic fire commands had left. Following the 40-millisecond cycle, the RSLS sets a flag to reset the MEC and then terminates operation.

(2) *Holddown Post 2 PIC Firing—Smoke Puff from Dome of Frangible Nut on Holddown Post*

Mission elapsed time: 00.008
Source: Camera E8

The E8 camera is stationary and is located on the mobile launch platform. It views the right SRB aft skirt and holddown posts from prior to ignition until after launch. At 00.008 second MET, the pyrotechnic initiator capacitor (PIC) firing is indicated by a small smoke puff from the dome of the frangible nut. On the top photo (figure 20), the first indication of this smoke is difficult to see without a frame-by-frame analysis. Also, the shadow obscures the smoke. The bottom photo is taken approximately 0.040 sec-

FIGURE 20



Camera E8 at 00.008 MET (left) and Camera E8 at 00.046 MET (right).

ond later, and shows that the smoke is clearly visible although somewhat obscured by the shadow cast on the holddown post.

(3) *First Continuous Vertical Motion*

Mission elapsed time: 00.250
Source: Camera E9

Figure 21 shows the first continuous vertical motion of the vehicle as the booster lifts from the pad and the luminous exhaust plume from the Solid Rocket Booster becomes prominent.

(4) *Confirmed Smoke Above Field Splice Initially Moves in + X Direction*

Immediately after solid rocket motor (SRM) ignition, dark smoke is observed billowing out from between the right SRB and the external tank. The exact location of the smoke source is not viewed directly. Visual analysis and image enhancement of film from five camera locations have been used to determine the approximate origin of the smoke in space and time, to characterize the dynamic behavior of the smoke, and to determine its longevity.

Mission elapsed time: 00.678
Source: Camera E60

The consensus opinion of the film interpreters is that smoke is first discernible at 00.678 second MET from camera E60. It becomes visible on other cameras shortly thereafter; **figure 22** presents views from two cameras showing the first evidence of the smoke. Based on these and other cameras, the smoke appears to be dark in color (brownish-gray under strong illumination and

The time relationship of the general-purpose computer (GPC) outputs to the EIU and master events controller to the run time for the softwater modules (RSLS, SSME, SOP, and MEC SOP) in the GPC 40-millisecond cycle are shown in the following:

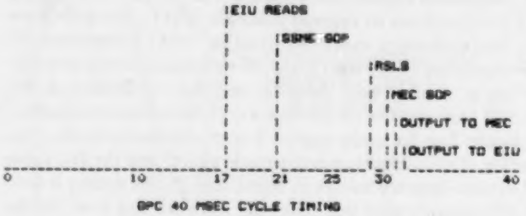
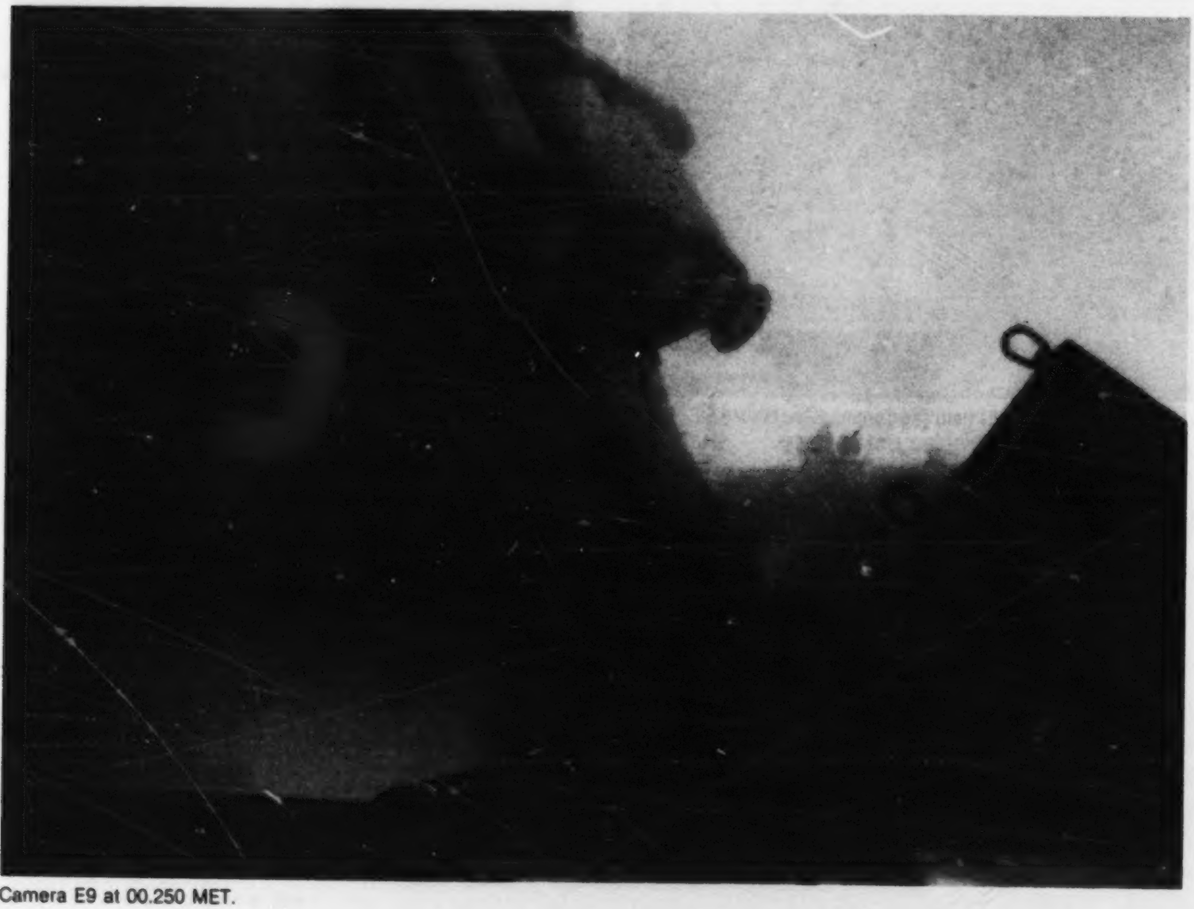


FIGURE 21



Camera E9 at 00.250 MET.

nearly black when shadowed) and is first seen above the aft to aft-center segment field splice as shown on the computer-aided design drawing of **figure 23**. The smoke appears to move upward in the +X direction in the next few frames after it first appears.

Figure 24 presents the viewing angles of all of the cameras which observed the smoke, and **figures 25 through 27** provide examples of the views from several of these cameras. The cross-hatched area of the CAD drawing in **figure 28** shows the region of the smoke origin determined to be between 270 degrees and 310 degrees clockwise from the +Z axis toward the ET.

(5) *Multiple Puffs of Smoke*

Mission elapsed time: 00.836 to 02.499
Source: Camera E63

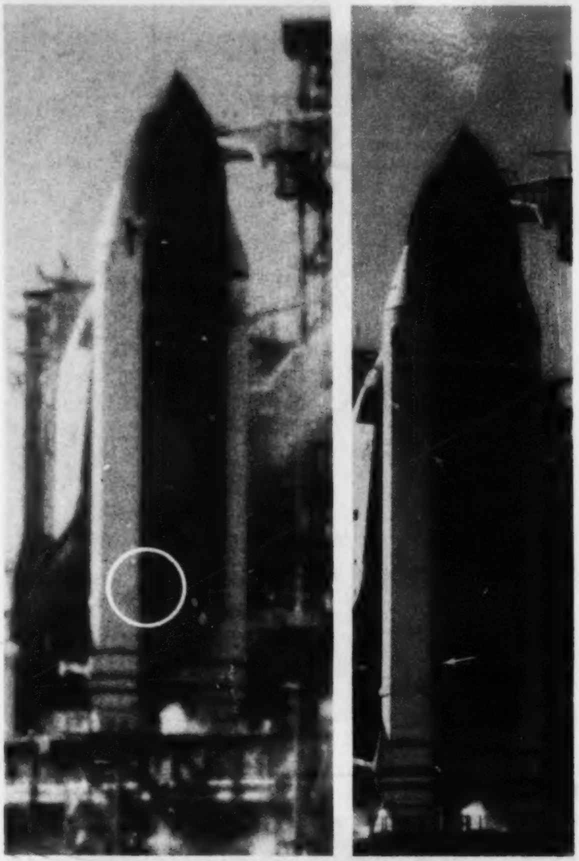
During the first few seconds after lift-off, the smoke appears to exhibit multiple puff characteristics. After an initial upward movement of a particular mass of smoke, the motion of the vehicle causes that mass to trail off rearward relative to the vehicle. A new puff of smoke is evidenced when another mass of smoke with relative upward movement compared to the previous puff is seen.

Figures 29 through 31 present photographs of the smoke during this time. **Figures 32 through 34** show motion analyzer plots (graphic depictions of the events as measured from the film) of the smoke cloud behavior from 02.064 seconds MET to 02.266 seconds MET. **Figures 32 and 33** show the rearward motion relative to the vehicle of a particular puff of smoke. **Figure 34** shows the development of a new puff in relation to the earlier one. **Figure 35** shows the relative motion of the top of the smoke in relation to a fixed reference. Smoke motions indicative of separate puffs are marked on the figure and have been identified beginning at the following times:

00.836 seconds MET
01.171 seconds MET
01.283 seconds MET
01.496 seconds MET
01.779 seconds MET
02.185 seconds MET
02.296 seconds MET
02.499 seconds MET

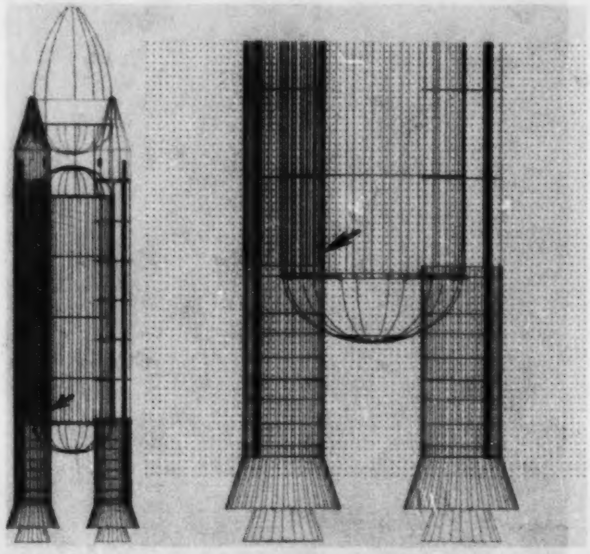
Since the point of origin of the smoke is not visible to the cameras, it is not certain that these separate puff motions are due to a pulsating source of smoke. Harmonic vehicle motions resulting from the lift-off "twang" could possibly account for some of the observed motion.

FIGURE 22



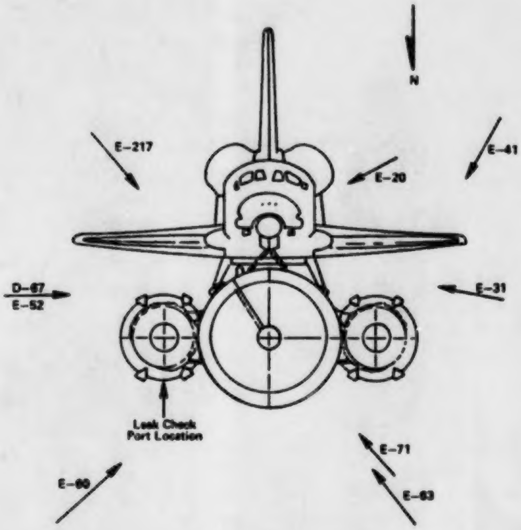
Camera CZR-1 at 02.733 MET (left) and Camera E60 at 02.738 MET (right).

FIGURE 23



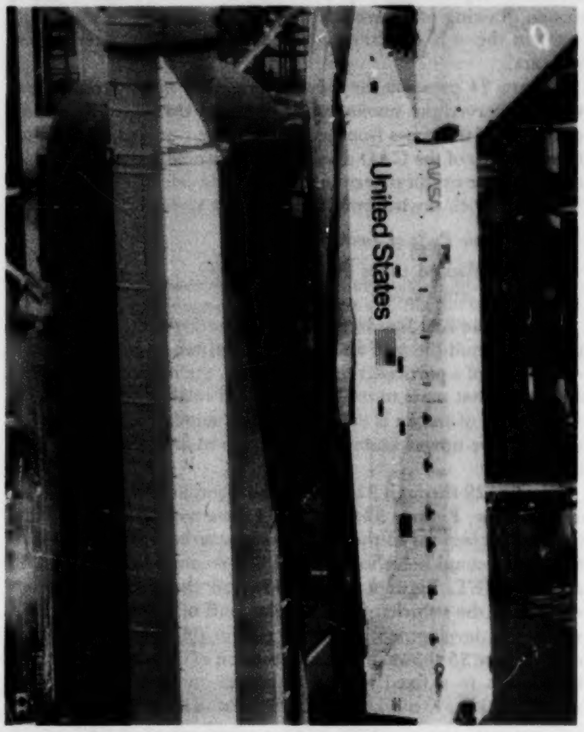
Wire-Frame CAD Drawing of Launch With Smoke Location Indicated.

FIGURE 24


N
E-217
E-20
E-41
D-67
E-52
E-31
Leak Check Port Location
E-60
E-71
E-63

Cameras Which Observed Smoke.

FIGURE 25


NASA
United States

Camera D67 at 01.600 MET.

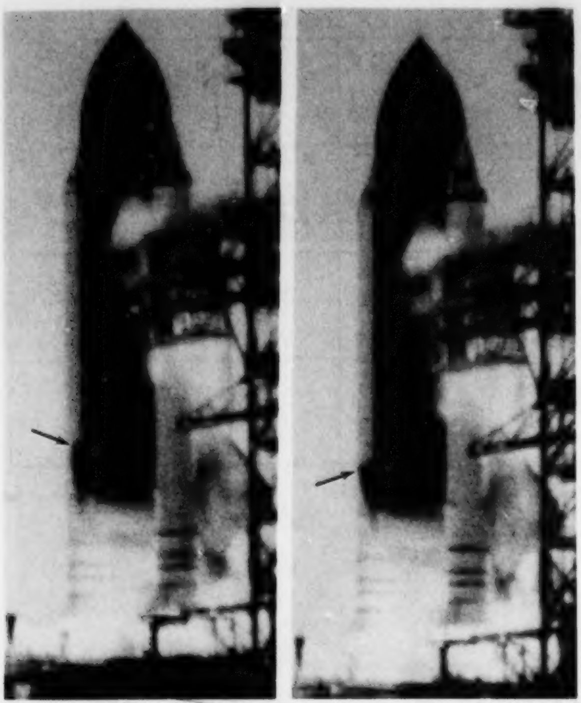
FIGURE 26

Camera E60 at 01.606 MET.

FIGURE 27

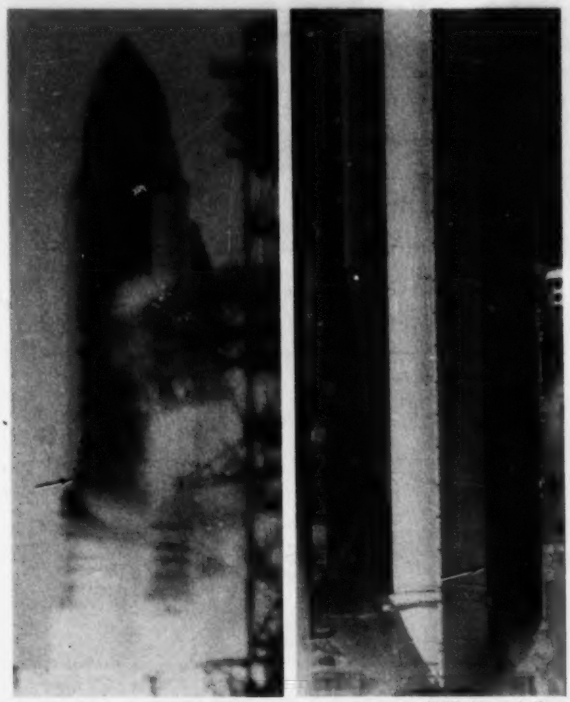
Camera E63 at 01.648 MET.

FIGURE 30



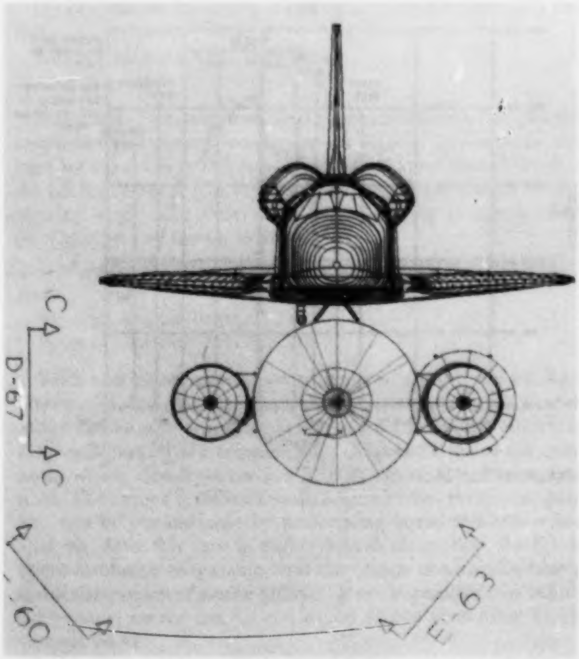
Camera E63 at 01.648 MET (left) and Camera E63 at 01.750 MET (right).

FIGURE 31



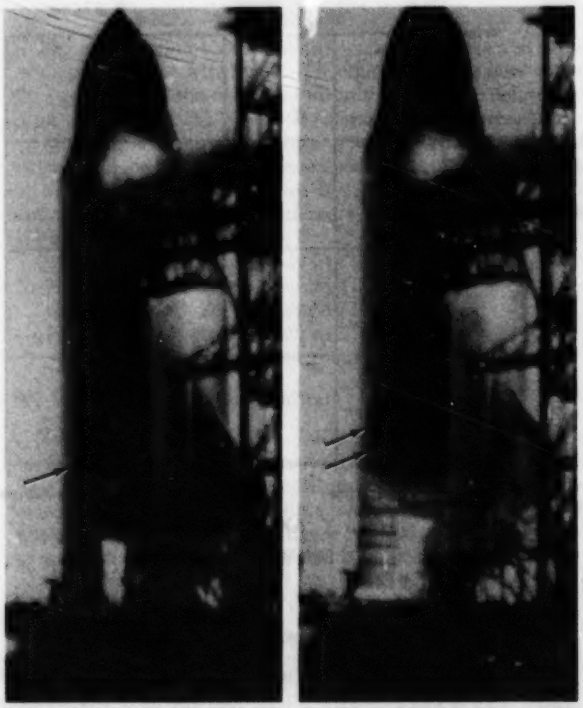
Camera E63 at 02.259 MET (left) and Camera D67 (exact time unknown) (right).

FIGURE 28



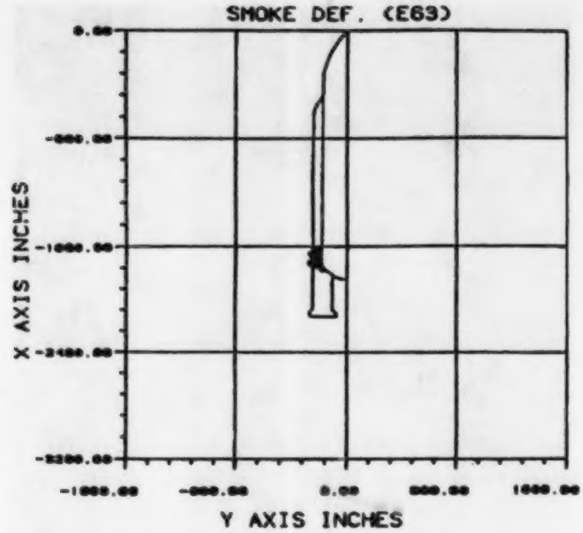
CAD Plan View with Launch Camera Views.

FIGURE 29



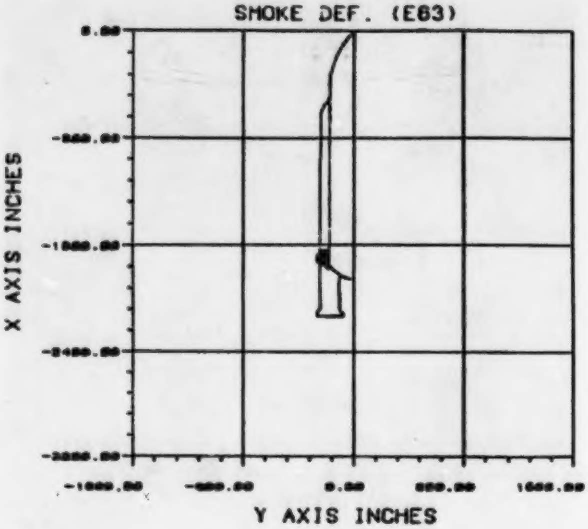
Camera E63 at 01.648 MET (left) and Camera E63 at 01.750 MET (right).

FIGURE 32



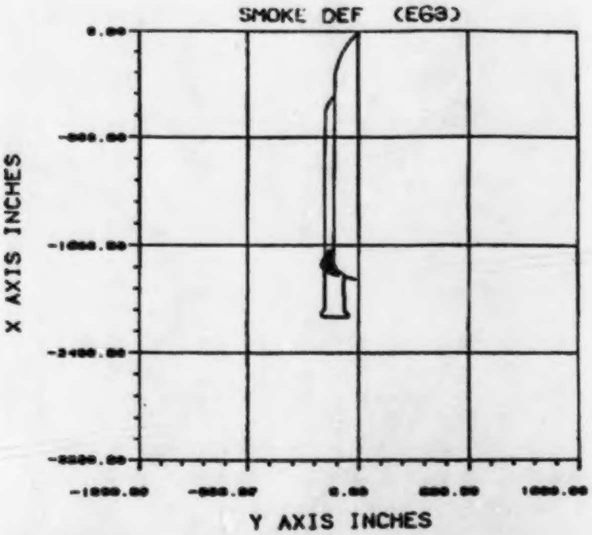
Smoke Puff Definition at 02.064 MET.

FIGURE 33



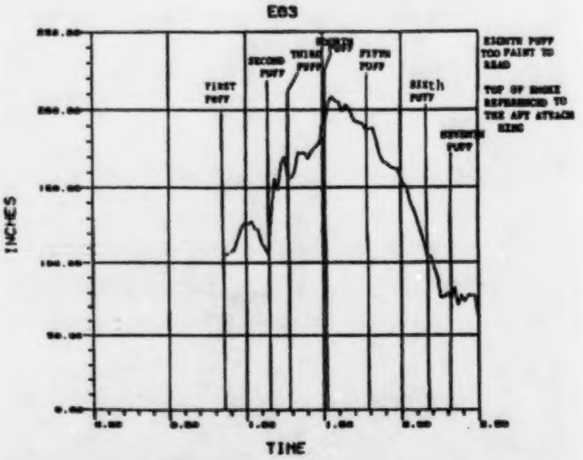
Smoke Puff Definition at 02.164 MET.

FIGURE 34



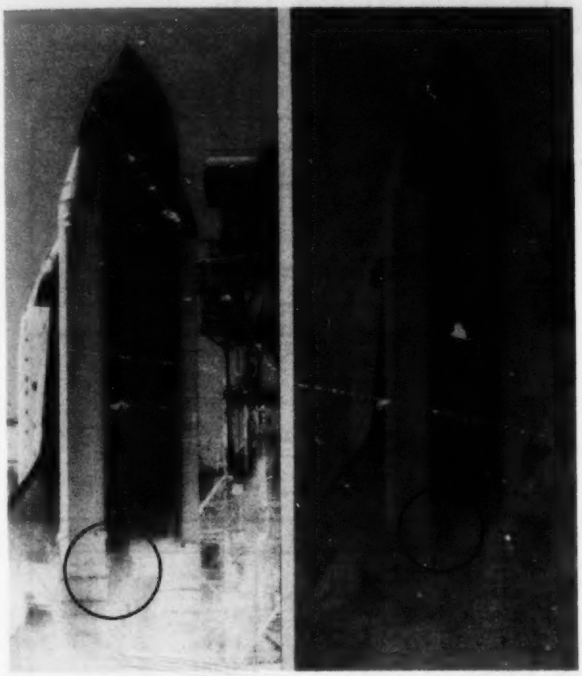
Smoke Puff Definition at 02.266 MET.

FIGURE 35



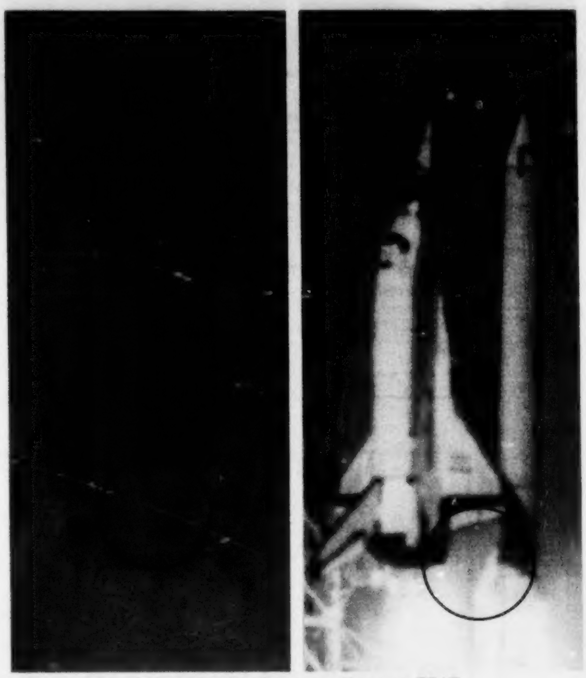
Motion of Top of Smoke Puff.

FIGURE 36



Camera CZR-1 at 02.733 MET (left) and Camera E60 at 02.738 MET (right).

FIGURE 37



Camera E60 at 03.375 MET (left) and Camera E217 (exact time unknown) (right)

(6) *Last Positive Evidence of Smoke Above Right Aft SRB/ET Attach Ring*

Mission elapsed time: 02.733
Source: Cameras CZR-1 and E60

The CZR-1 camera was used to determine the last positive evidence of smoke above the right aft SRB/ET attachment ring because the detail in the picture allows accurate identification of the SRB structure. The E60 camera photograph from a similar viewing angle and time offers corroborating evidence. Both photographs are shown in **figure 36**.

(7) *Last Positive Visual Indication of Smoke Dispersing Below ET Aft Dome*

Mission elapsed time: 03.375
Source: Cameras E60 and E217

With increasing upward velocity of the vehicle, the smoke is dispersed below the vehicle. The last positive visual indication of the smoke as it disperses below the ET aft dome is seen on camera E60 at 03.375 seconds MET. **Figure 37** shows this event along with a view from camera E217 at approximately the same time. The smoke is difficult to distinguish from the plume gases and can be tracked only by performing frame-to-frame visual analysis. After this time in flight, the vehicle motion, the ET aft dome insulation outgassing, and the vehicle plumes combine to make observation of smoke difficult, if not impossible. No definite evidence of smoke can be confirmed at any time after 03.375 seconds MET.

(8) SSME Throttle Commands — 104 Percent

The main engine 1 and 2 vehicle commands occurred prior to the main engine 3 command. Therefore, the times selected for the completion of the command throttle events were defined by using E41M3076D (ME-3 vehicle command). ME-3 vehicle command E41M3076D is a 25-sample/second measurement located in the 60-kilobit MSFC data stream with an established tolerance of +0.045, −0.035 second (see figure 38). These are normal ascent events to be used for reference only. The times selected are as follows:

104 percent — 04.364 seconds MET
94 percent — 19.885 seconds MET
65 percent — 35.406 seconds MET
104 percent — 51.886 seconds MET

(9) Vehicle Roll Program Initiate

The vehicle roll program initiate data were taken from V90R5301C [selected rate gyro accelerometer (RGA) roll rate]. This measurement has a 5-sample/second sample rate which corresponds to a +000, −0.20 time tolerance. The time selected was 07.724 seconds MET (see figure 39). This is a normal ascent event to be used for reference only.

(10) SSME 94 Percent Command

This command is shown on figure 38.

FIGURE 38

SSME Engine Throttle Commands.

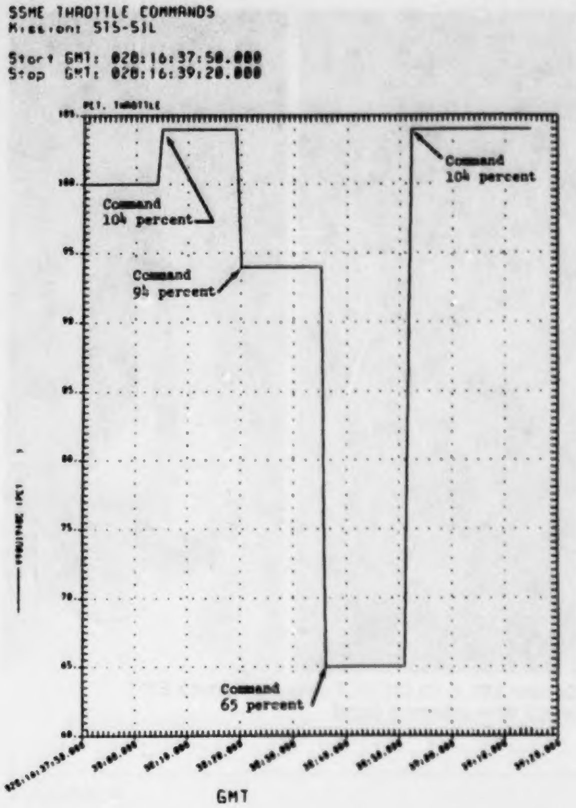
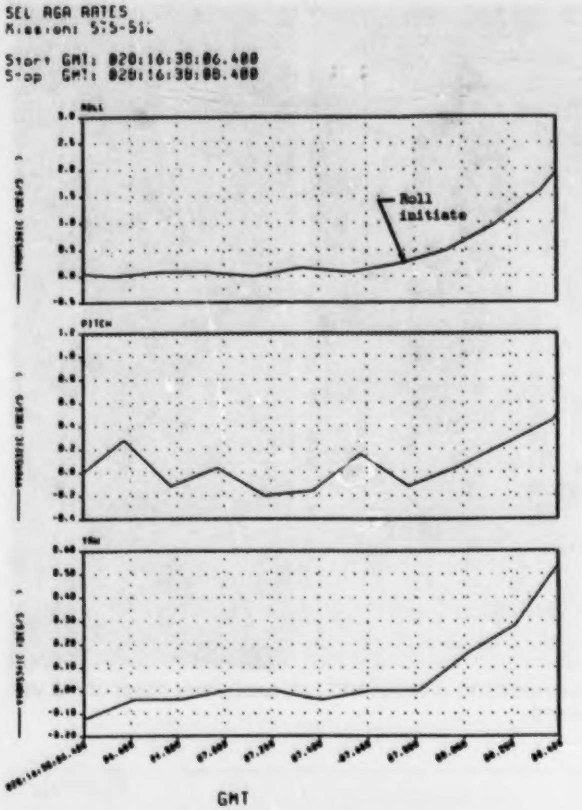


FIGURE 39

Vehicle Roll Program Initiate.



(11) Vehicle Roll Program Complete

The vehicle roll program complete data were taken from V90R5301C (selected RGA roll rate). This measurement has a 5-sample/second sample rate which corresponds to a +000, −0.20 time tolerance. The selected time was 21.124 seconds MET (see figure 40). This is a normal ascent event to be used for reference only.

(12) Start Right SRB Maximum Dynamic Pressure Bucket

The start of the SRB maximum dynamic pressure bucket was defined using measurement B47P1302C for the left SRB chamber pressure and B47P2302C for the right SRB chamber pressure (see figure 41). The measurements used have a 12.5-sample/second sample rate which corresponds to an accuracy tolerance of 0.080 second. The time of the event is 21.604 seconds MET which is the first data sample after the slope change.

Right SRB—21.604 second

(13) Start Left SRB Maximum Dynamic Pressure Buck

The start of the left SRB maximum dynamic pressure is 22.204 seconds MET and was derived as in event (12).

(14) SSME 65 Percent Command

This command is shown on figure 38.

(15) Interval of Roll and Yaw Attitude Error "Response to Wind"

During the interval from 36.990 to 62.990 seconds MET, the roll and yaw attitude errors that were observed have been identified as responses to ascent winds (see figure 42). The measurements selected to bound this interval are body yaw attitude error (V95H3522C) and body roll attitude error (V95H3523C).

(16) SSME 104 Percent Command

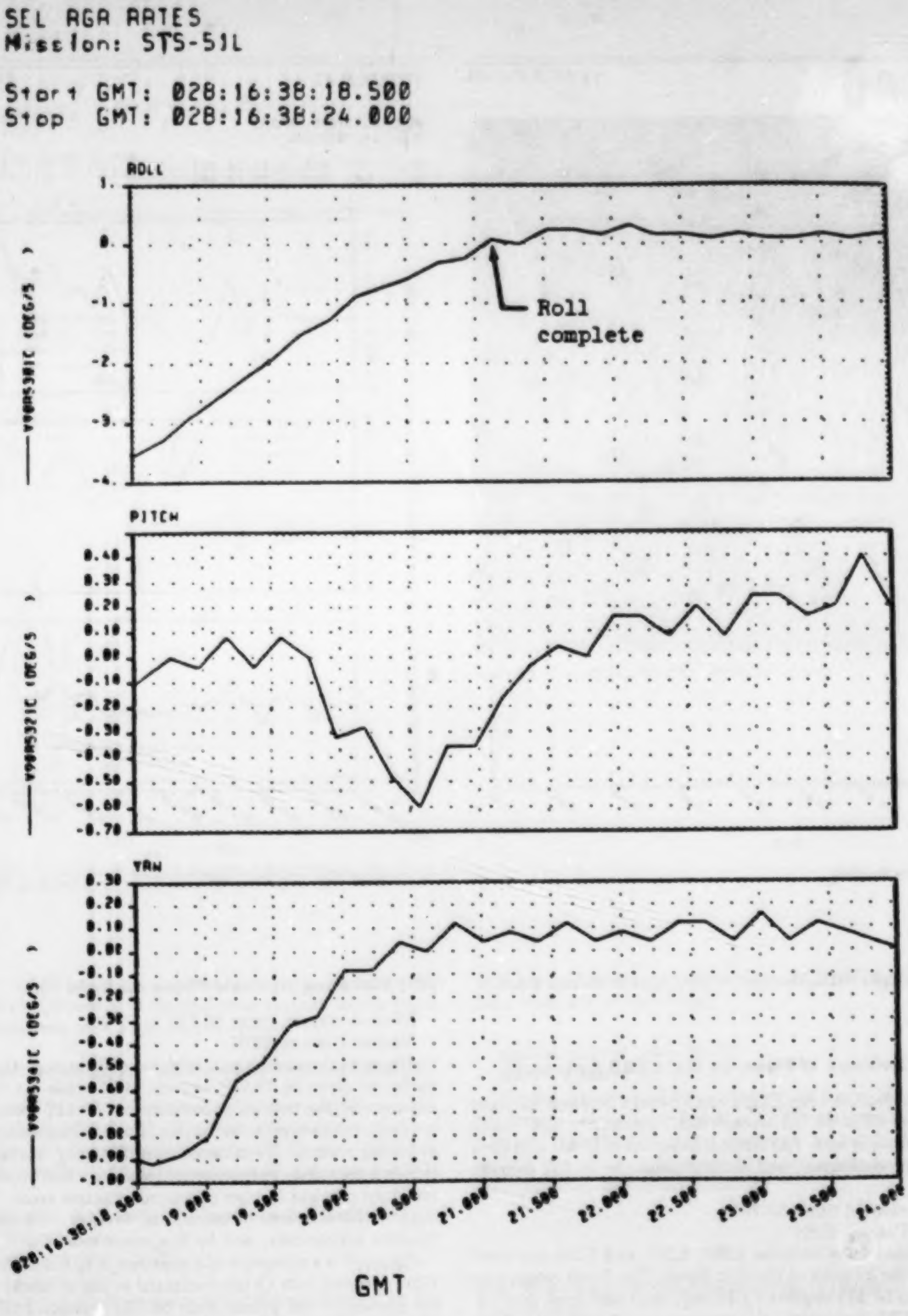
The command is shown on figure 38.

(17) End Left SRB Maximum Dynamic Pressure Bucket

The end of the SRB maximum dynamic pressure bucket was defined using measurement B47P1302C for the left SRB chamber pressure and B47P2302C for the right SRB chamber pressure. The measurements used have a 12.5-sample/second sample rate which corresponds to an accuracy tolerance of 0.080 second. The time of the event was established by selecting the first data sample from both measurements reflecting a chamber pressure increase after the minimum SRB chamber pressure maximum dynamic pressure bucket (see figure 43). The selected times for the events are:

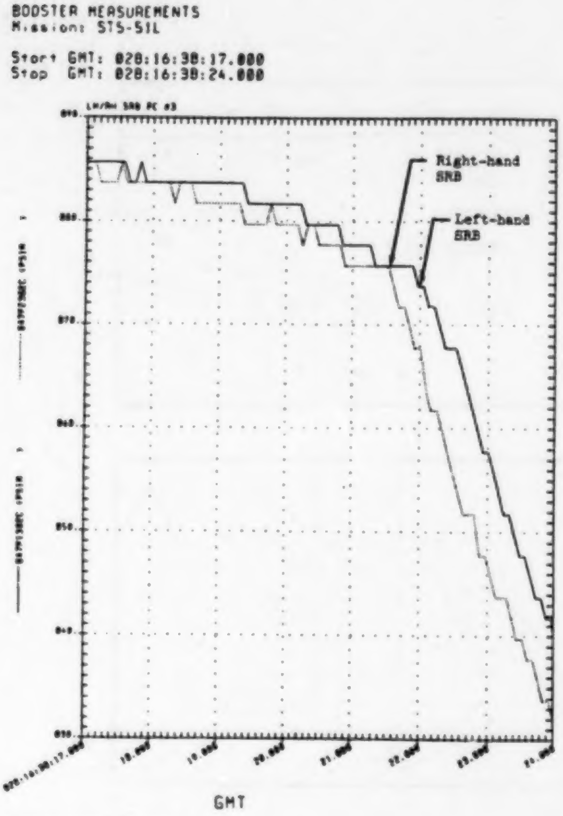
Left SRB—54.124 seconds MET
Right SRB—54.324 seconds MET

FIGURE 40



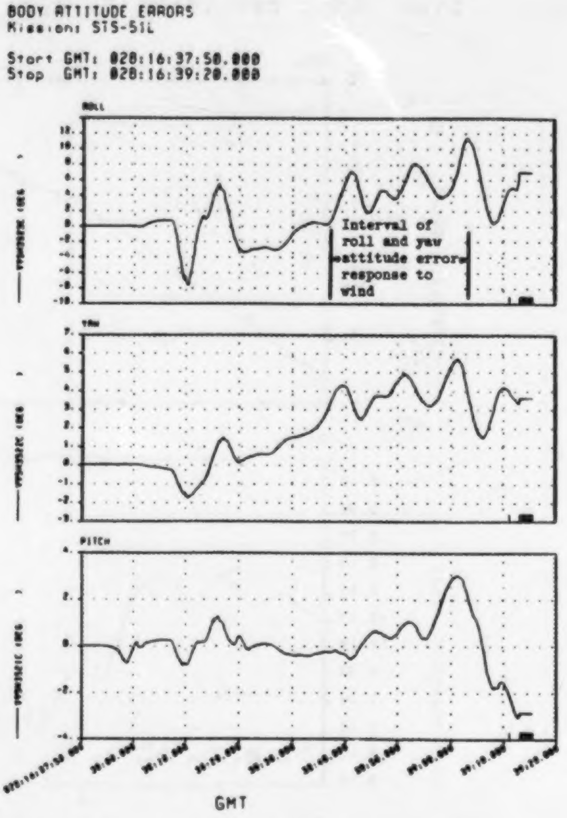
Vehicle Roll Program Complete

FIGURE 41



SRB Throttle Bucket.

FIGURE 42



Interval of Roll and Yaw Attitude Error Response to Wind.

(18) End Right SRB Maximum Dynamic Pressure Bucket

See (17).

(19) First Evidence of Flame on Right SRB (enhanced)

The flame from the right SRB was first seen between the right SRB and the ET at 58.762 seconds MET on camera E207 using imagery enhancement. The flame is observed to flicker and then grow into a continuous, well-defined plume at 59.262 seconds MET.

Mission elapsed time: 58.762
Source: Camera E207

Photography from cameras E203, E207, and E216 was used to identify the location of the first flame. The flame origin was estimated to be 315 degrees (± 10 deg) clockwise from the +Z axis of the SRB towards the ET and near the aft field joint. This estimate was produced by the use of an image analysis system. Figure 44 with a CAD overlay shows the earliest detection of the flame on E207 at 58.762 seconds MET.

(19) First Evidence of Flame on Right SRB

Mission elapsed time: 58.788
Source: Camera E207

Figure 45 shows the first evidence of flame on the right SRB. This is only one frame later than the enhancements could detect.

(20) Flickering Dynamic Plume on Right SRB

Mission elapsed time: 58.762 to 59.262
Source: Camera E207

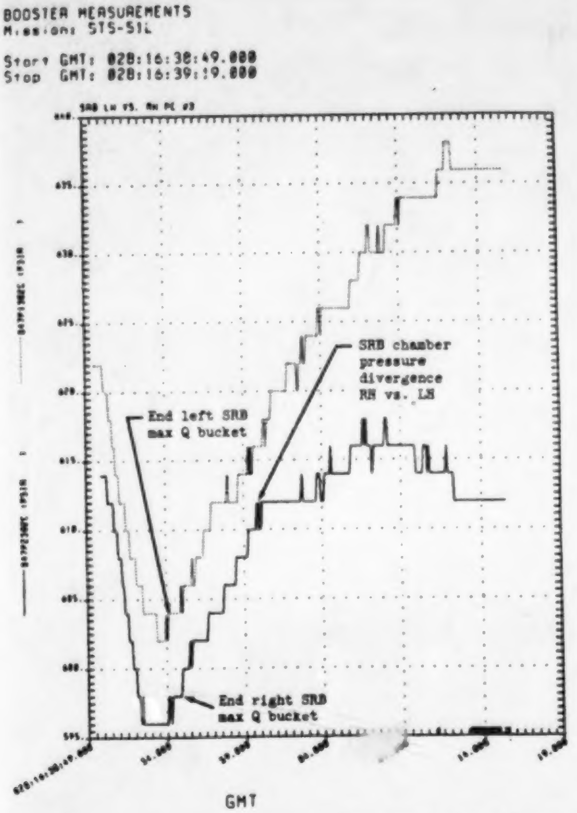
Figure 46 shows the visual evidence of flickering. The top photo shows the flame at 59.087 seconds MET while the flame is not apparent in the bottom photo taken at 59.112 seconds MET.

Image enhancements by various organizations detected the leak at 58.762 seconds. Verification that flickering was seen directly (not as a reflection) was confirmed by the fact that brightness levels remained constant in other presumed reflection areas. The flickering was characterized by maximum, average, and minimum intensities versus time, and by frequency analysis.

Figure 47 is a composite of a sequence of 40 frames from camera E207 (printed with Orbiter oriented at top of stack) and shows the growth of the plume from 58.762 seconds MET through 59.661 seconds MET. The white boxes outline the location of the plume. The intermittent nature of the plume is observed. Fluctuations in intensity can be seen between 58.788 seconds MET and 59.262 seconds MET. At 59.262 seconds MET, the plume becomes well established and continues to grow, although some variation in intensity is still evident.

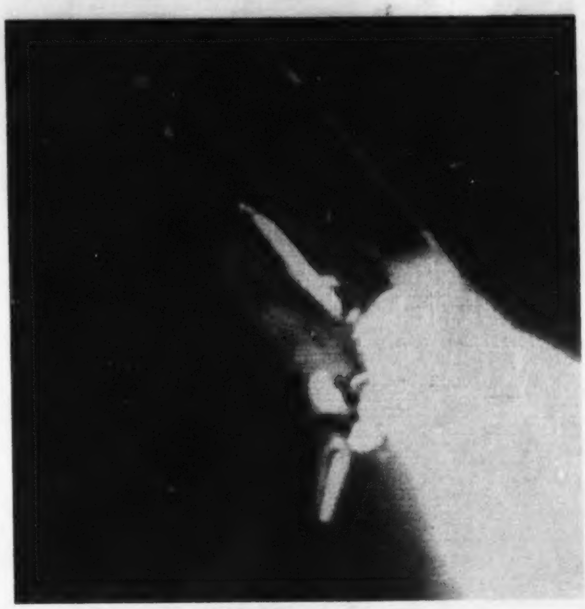
Figure 48 depicts the flame without any background data or reflections. This was accomplished by electronically subtracting the image with no flame visible (frame 20 of figure 48) from frames 21 to 59. The maximum brightness level of these resultant images is plotted in figure 49. Figure 50 shows a power density spec-

FIGURE 43



SRB Maximum Dynamic Pressure Bucket and Chamber Pressure Divergence

FIGURE 44



Camera E207 at 58.762 MET With CAD Inlay.

trum of the maximum intensity of the flame from the right SRB. The dominant frequency of the flickering is every fourth frame which corresponds to a pulse rate of 10/sec.

(21) Reconstructed Maximum Dynamic Pressure (720 psf)

The maximum dynamic pressure in pounds per square foot (psf) was derived using the lift-off + 10 minutes rawinsonde wind data and the best estimate of trajectory (BET) (see figure 51). The maximum value of 720 psf occurred at 59.000 seconds MET.

(22) Continuous Well-Defined Plume on the Right SRB in + Z, − Y Coordinates

Mission elapsed time: 59.262
Source: Camera E207

The flame became a continuous well-defined plume at 59.262 seconds MET, although it continued to vary in intensity as shown in figure 52. The CAD drawing gives the approximate location of the flame source.

Several image analysis techniques were employed to ascertain the origin of the plume on the right SRB. Figure 53 shows a frame from camera E207 at 59.487 seconds MET with CAD overlay. Figure 54 shows a frame from camera E-216 at 59.507 seconds MET registered with the appropriate CAD drawing. The flame origin was estimated to be at 45 degrees (+ or − 10 degrees) from the + Z axis of the right SRB toward the ET and near the aft field joint.

(23) Visual Evidence of Flame from Right SRB in + Z Direction Near ET Attach Ring

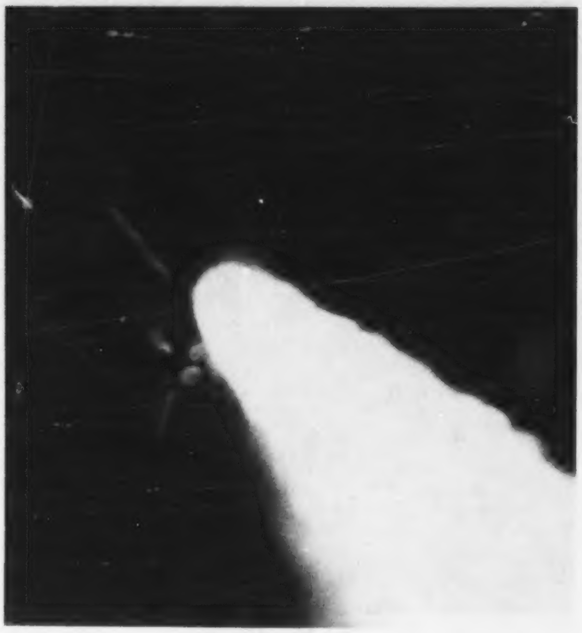
Mission elapsed time: 59.753
Source: Camera E204

The first evidence of flame as shown in figure 55 is seen from the south at Melbourne Beach at 59.753 seconds MET, almost a second later than it can be seen from the north. This view is slightly out of focus because the camera was focused for the nominal SRB separation distance.

(24) SRB Chamber Pressure Divergence (Right Hand Versus Left Hand)

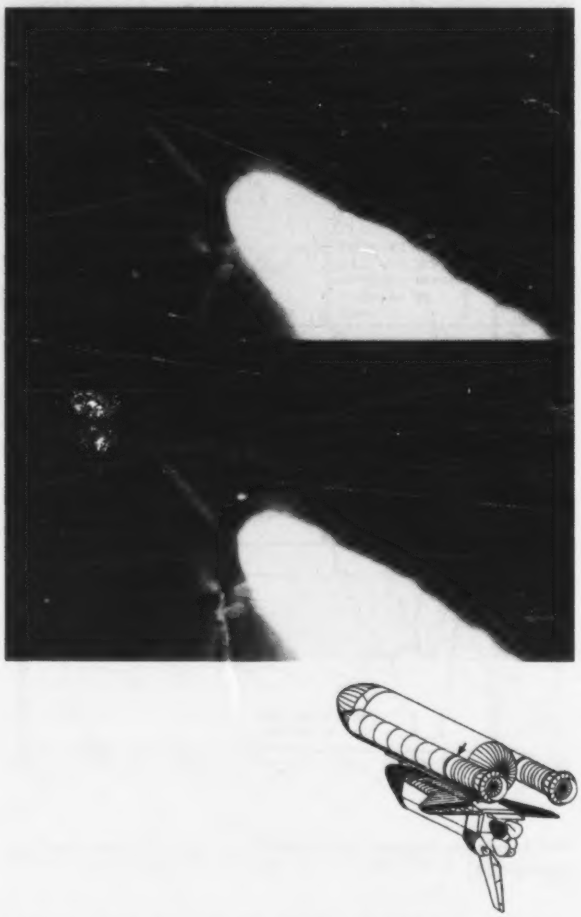
The start of the SRB chamber pressure divergence (right versus left) was defined using measurement B47P1302C for the left SRB chamber pressure and B47P2302C for the right SRB chamber pressure. The measurements used have a 12.5-sample/second sample rate which corresponds to an accuracy tolerance of 0.080 second. The time of the event was established using measurement B47P2302C at the second data sample of the flat chamber pressure (see figure 43). The established event time for the right SRB is 60.004 seconds MET.

FIGURE 45



Camera E207 at 58.788 MET (above) and Hidden-Line CAD Drawing with Plume location indicated (right)

FIGURE 46



Camera E207 at 59.087 MET (top) and 59.112 MET (Bottom) and Hidden Line CAD Drawing With Plume Location Indicated (right).

(25) First Evidence of Plume Deflection Intermittent

Mission elapsed time: 60.238
Source: Camera E207

As the plume from the side of the right SRB increased in size, it was impinging on the external tank and deflected by aerodynamic forces. The plume deflection was intermittent. The first evidence of the plume deflection through visual analysis is at 60.238 seconds MET and is best seen first from camera E207 (see figure 56). A second photograph from camera E207 taken 0.223 second later shows the deflection of the plume more clearly. (See figure 57).

(26) First Evidence of Anomalous SRB Plume Attaching to theme

Mission elapsed time: 60.248
Source: Camera E203

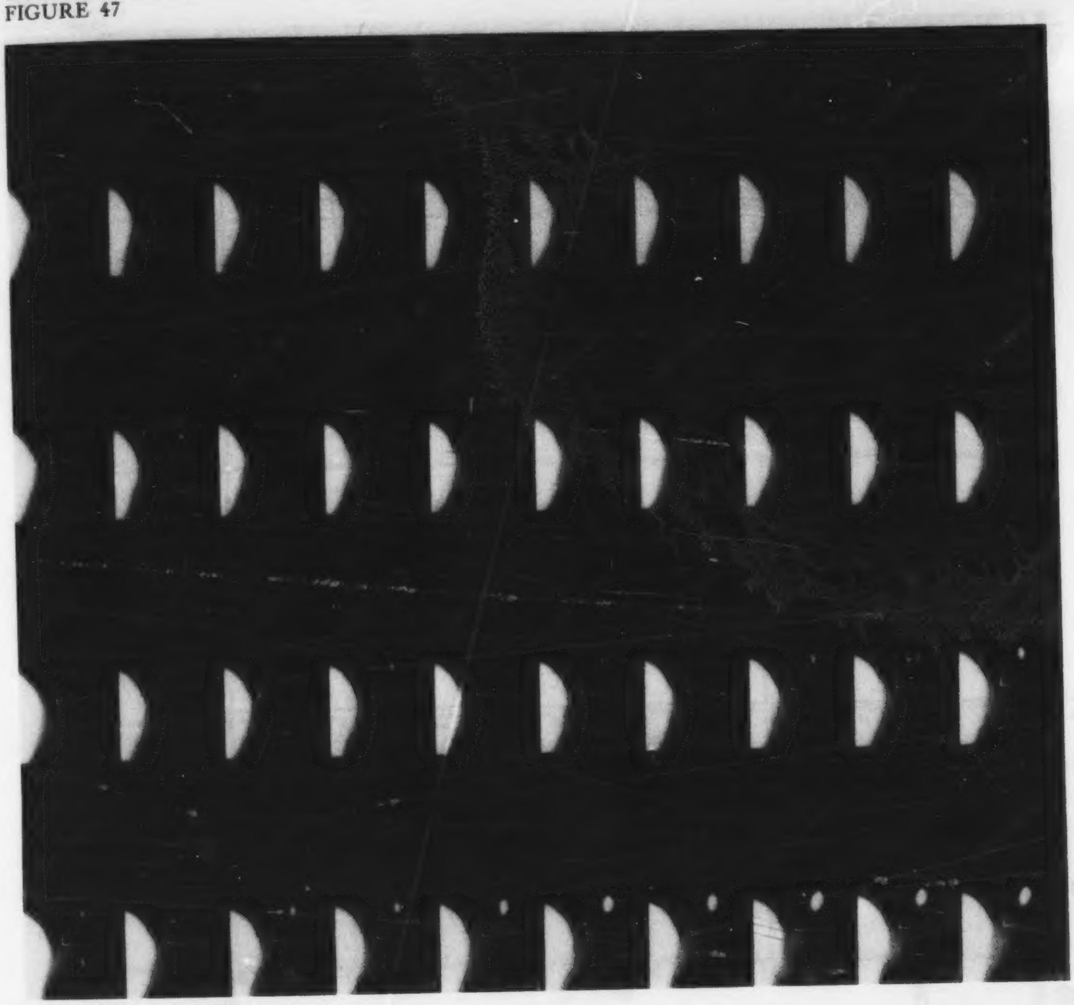
Figure 58 shows a view of the vehicle from almost directly aft with only parts of the SRB's and ET visible. The vehicle is difficult to identify because the film is exposed for plume characteristics. However, the anomalous plume is very prominent. Visual analysis shows that the growing plume arcs around some 60° of the external tank structure at the 2058 ring frame. The location was verified by using an image analysis system to overlay CAD drawings on the images. The first frame on which this event can be identified is from camera E203 at 60.248 seconds MET, but the event is better depicted from the same camera at 60.614 seconds MET.

(27) First Evidence of Plume Deflection—Continuous

Mission elapsed time: 60.988
Source: Camera E207

Continuous deflection of the plume is first apparent on camera E207 at 60.988 seconds MET as shown in figure 59. From this time, the plume grows rapidly, eventually obscuring the lower section of the ET, as depicted on the annotated CAD drawing.

FIGURE 47

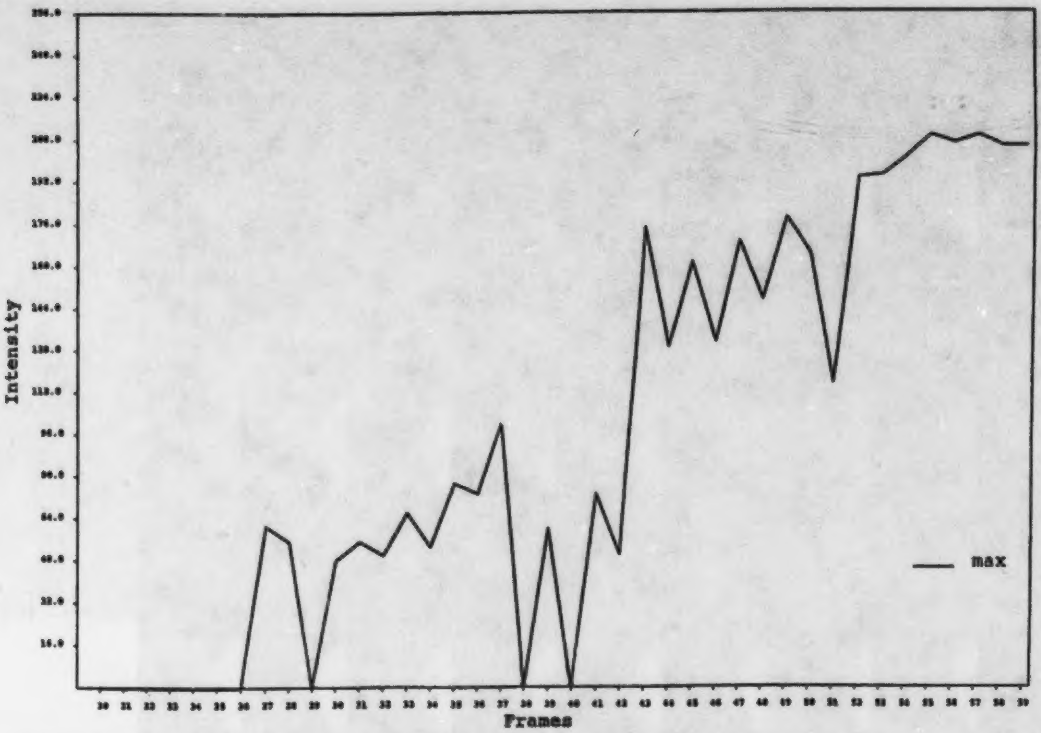


Camera E207 Composite

FIGURE 48

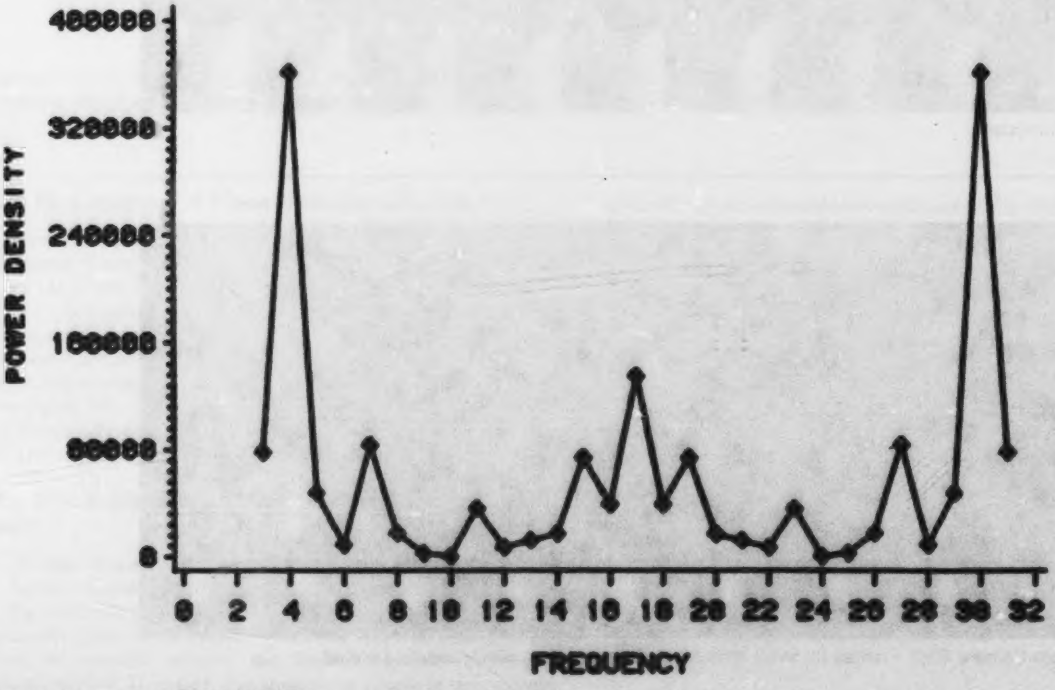
Flame Seen From Camera E207 Frames 20 to 59 With All Background Data Electronically Deleted.

FIGURE 49



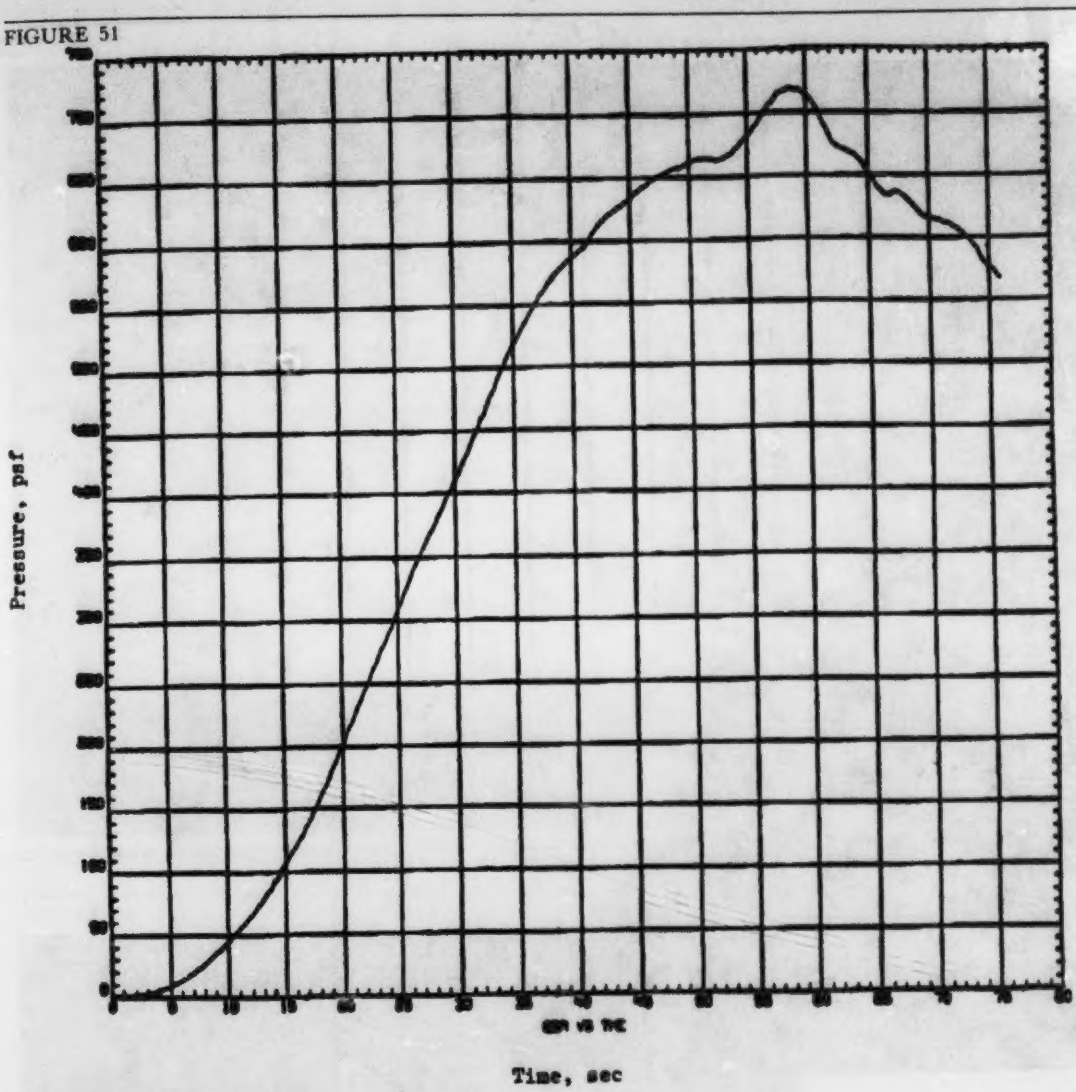
Maximum Brightness Level of the Flame Seen From Camera E207 Frames 20 to 59.

FIGURE 50



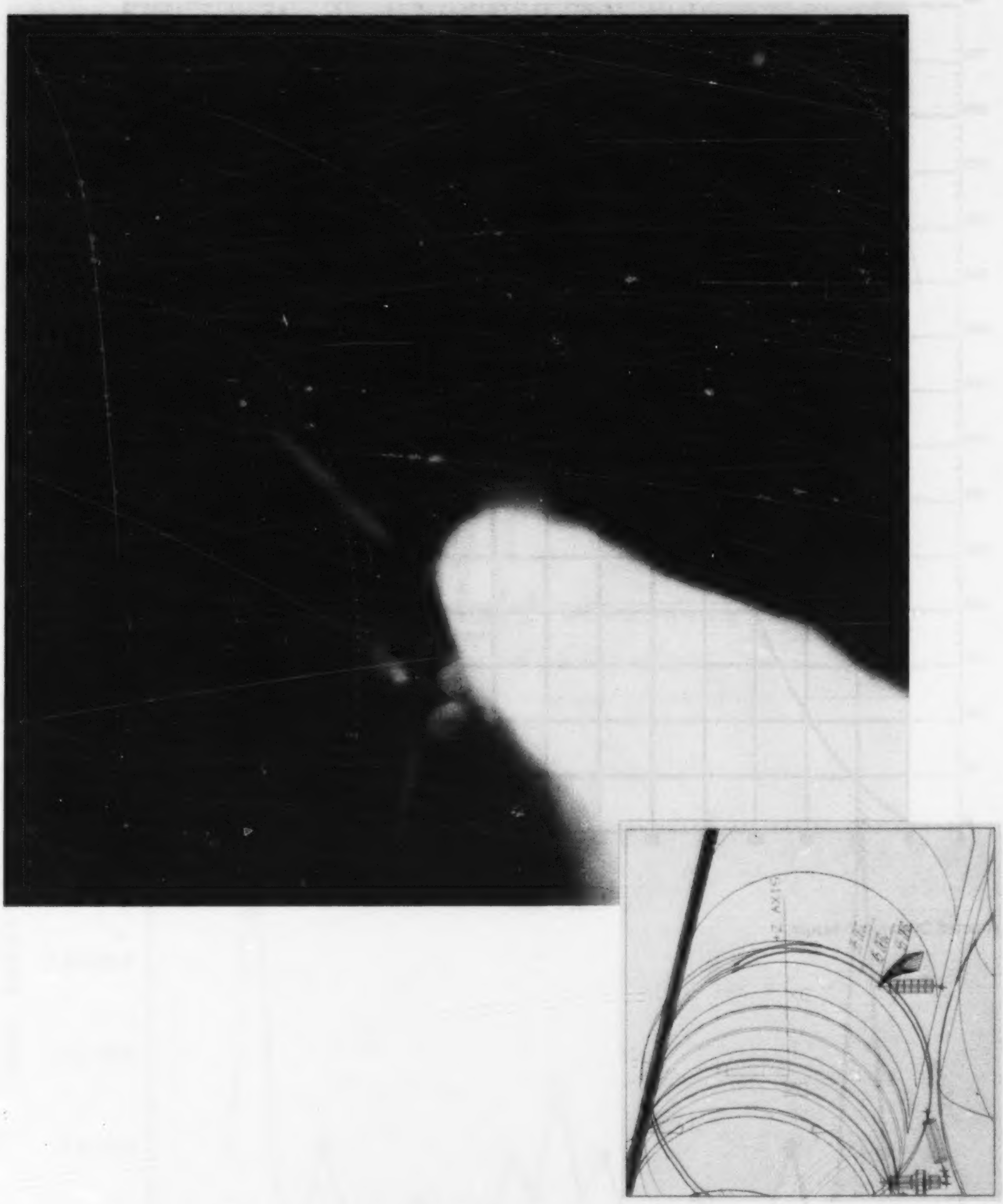
Power Spectrum of Flame Intensity.

FIGURE 51



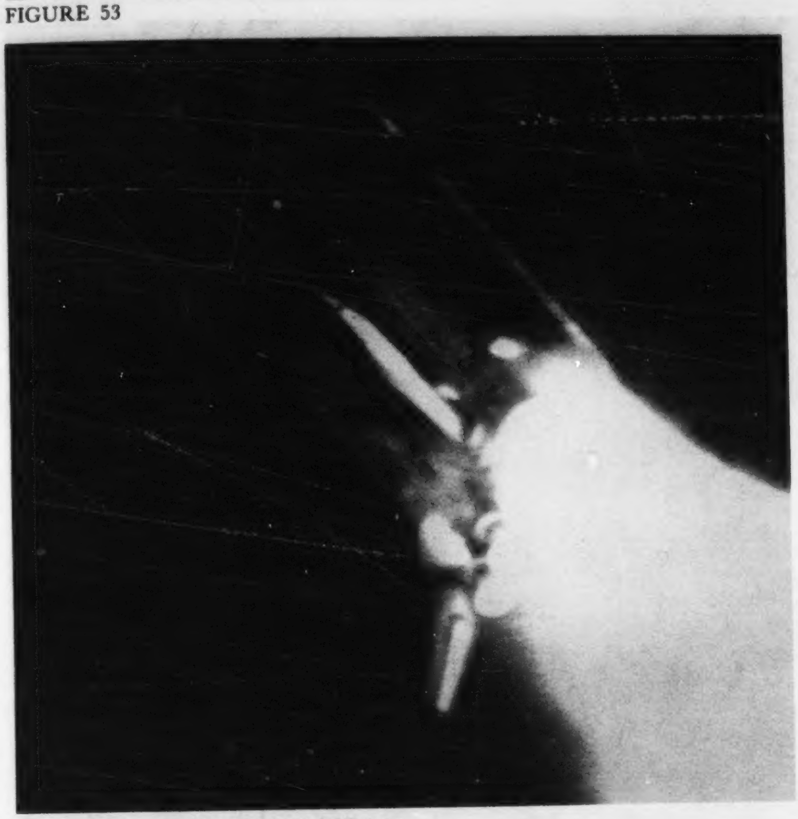
Reconstructed Dynamic Pressure.

FIGURE 52



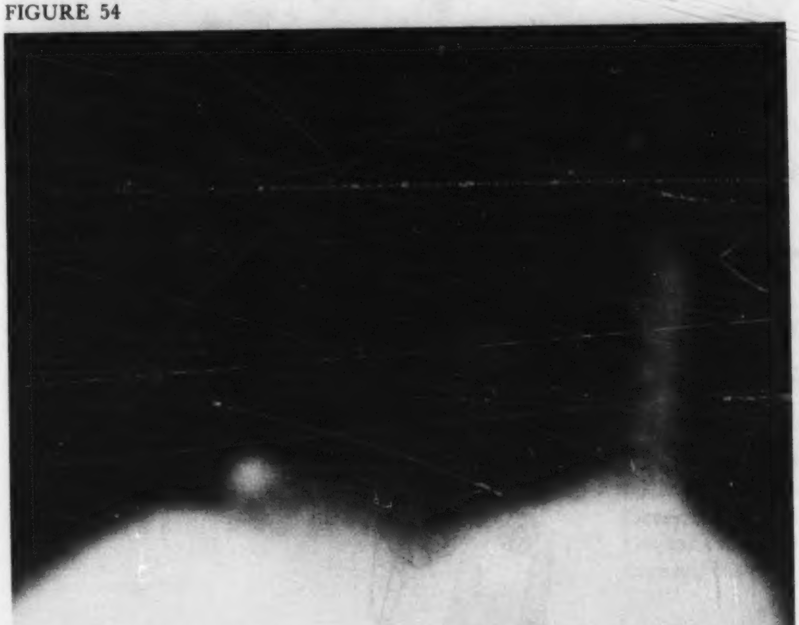
Camera E207 at 59.262 MET (above) and Wire-Frame CAD Drawing (Right).

FIGURE 53



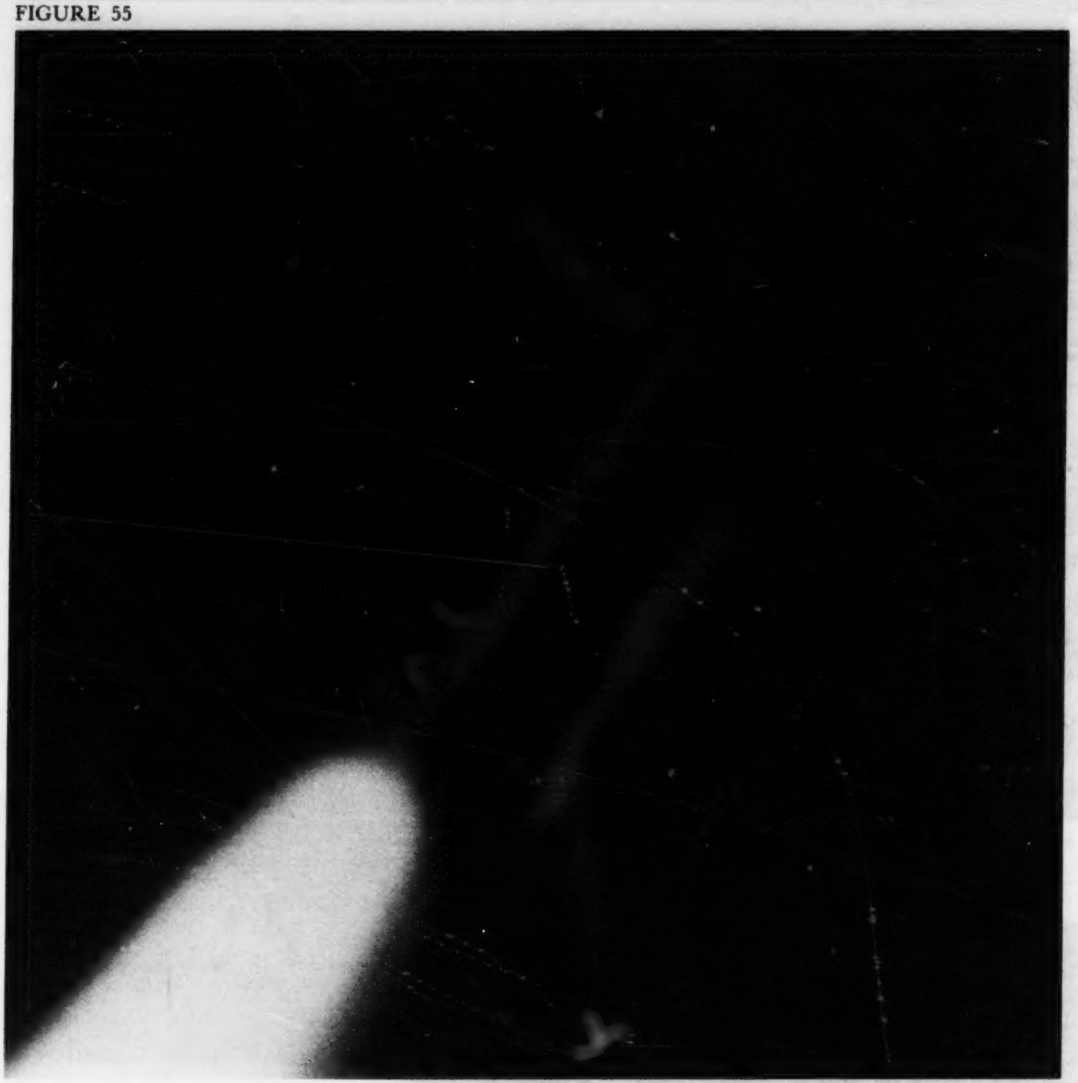
Camera E207 at 59.487 MET With CAD Inlay.

FIGURE 54



Camera E216 at 59.507 MET With CAD Inlay.

FIGURE 55



Camera E204 and 59.753 MET (above) and CAD Drawing (right)
Photograph taken at 60.586 MET.

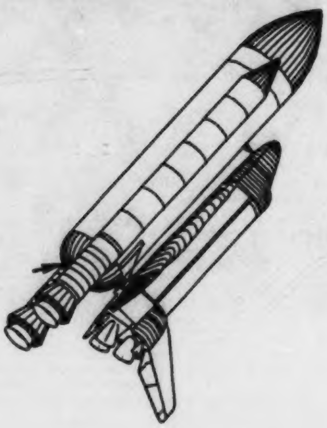
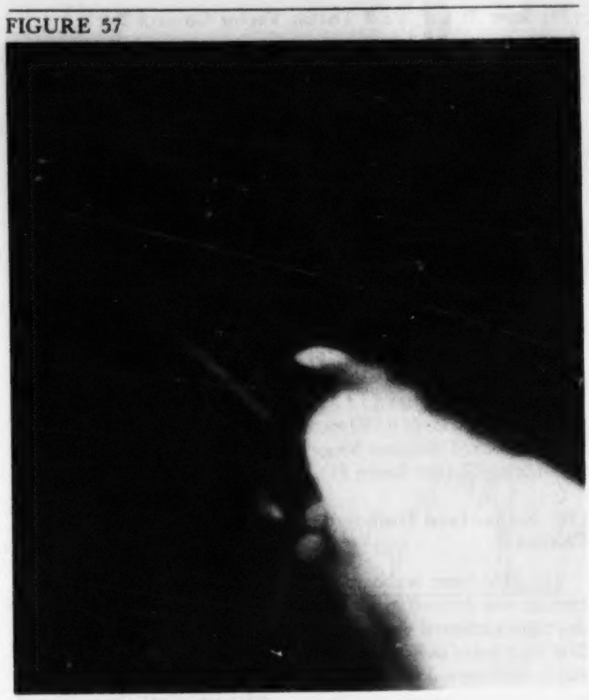


FIGURE 56

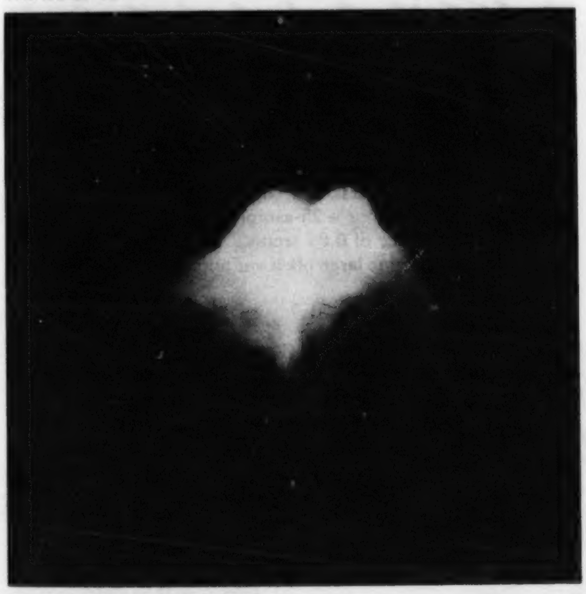
Camera E207 at 60.238 MET.

FIGURE 57



Camera E207 at 60.461 MET

FIGURE 58



Camera E203 at 60.614 MET.

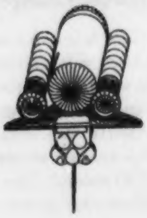
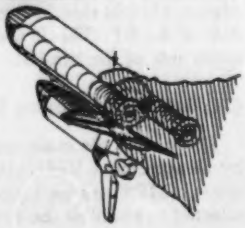


FIGURE 59

Camera E207 at 60.988 MET (above) and Annotated CAD Drawing (right).



(28) Start of Left SRB Thrust Vector Control Rock Actuator Spike

The start of the left SRB thrust vector control actuator spike was taken from measurement B58H1150C (see figure 60). This measurement has a sample rate of 25 samples/second which results in a time tolerance of 0.040 second. The event time selected, 62.094 seconds MET, is the data point defining the maximum rock actuator negative position prior to loss of data.

(29) Right-Hand Outboard Elevon Actuator Hinge Moment Spike

The right-hand outboard actuator hinge moment spike was defined using the right outboard elevon primary differential pressure 1 measurement (V58P0966C). The first data point depicting the peak of the actuator hinge moment spike was selected. The measurement has a 12.5-sample/second sample rate with an accuracy tolerance of 0.080 second. The selected time of the right-hand outboard actuator hinge moment spike peak was 62.484 seconds MET (see figure 61).

(30) Right-Hand Outboard Actuator Differential Pressure Change

The right-hand outboard elevon actuator differential pressure change was defined using measurement V58P0966C, which is the right outboard elevon primary differential pressure 1. The first data point indicating the unexpected change in right-hand elevon differential pressure was selected. The measurement has a 12.5-sample/second sample rate with an accuracy tolerance of 0.080 second. The time of the right-hand outboard elevon actuator differential pressure change was 63.924 seconds MET (see figure 61).

(31) Start Vehicle Pitch-Rate Change

The start of the vehicle pitch-rate change was defined using measurement V90R2525C, which is the left SRB pitch rate. The first data point which reflects the start of the vehicle pitch-rate change was selected to establish the time of the event. The pitch-rate change measurement has a 5-sample/second sample rate with an accuracy tolerance of 0.2 second. The start time of the vehicle pitch-rate change was 64.604 seconds MET (see figure 62).

(32) Abrupt Change in Anomalous Plume Shape; First Indication of Liquid Hydrogen Leak Near ET 2058 Ring Frame

Mission elapsed time: 64.660
Source: Camera E204
An abrupt change in the shape of the anomalous plume occurs at 64.660 seconds MET and is the first indication of a hydrogen leak. This change is shown in figure 63. This leak is corroborated by changes in the ET hydrogen pressurization system beginning at 66.674 seconds MET.

(33) Bright Sustained Glow on +Z and −Z Sides of ET

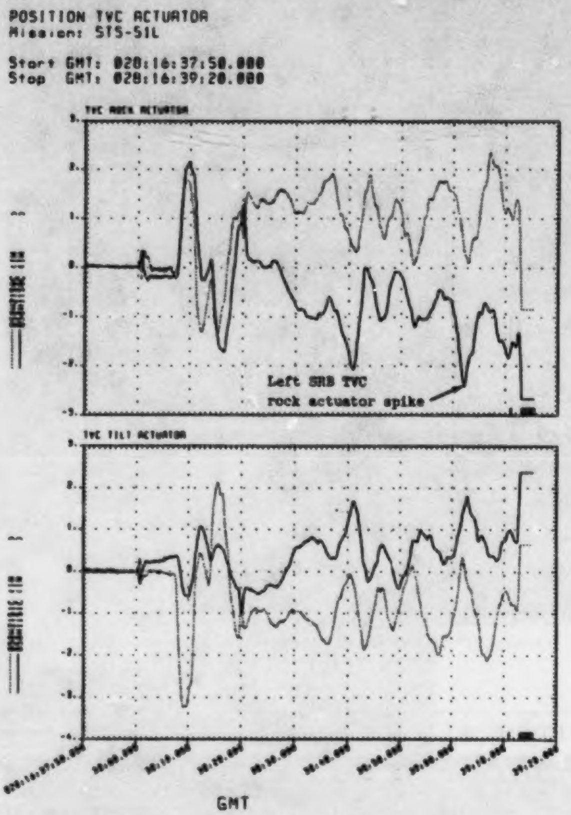
Mission elapsed time: 64.705
Source: Camera E204
Within .045 second after the abrupt change in the anomalous plume, a bright sustained glow is noted on both the +Z and −Z side of the ET. This is shown in figure 64 as viewed from the south side of the vehicle.

(34) Start Main Engine Large Pitch Variations

The start of the main engine large pitch variations is defined by measurement V68H11OOA, which is the main propulsion system (MPS) engine 1 pitch-actuator position. The data point selected to establish the time of the event is the first point that reflects the start of the main engine large pitch variations.

This measurement has a 25-sample/second sample rate with an accuracy tolerance of 0.04 second. The selected time of the start of the main engine large pitch variations was 64.937 seconds MET (see figure 65).

FIGURE 60



Left SRB TVC Rock Actuator Spike.

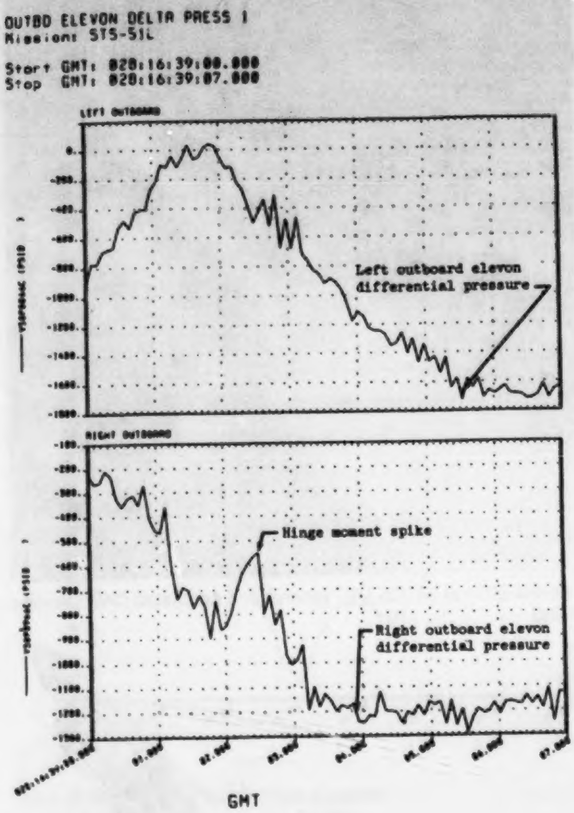
(35) End Vehicle Pitch-Rate Change

The end of the vehicle pitch-rate change is defined using measurement V90R2525C, which is the selected left SRB pitch rate. The first data point which reflects the end of the vehicle pitch-rate change was selected to establish the time of the event. The pitch-rate change measurement has a 5-sample/second sample rate with an accuracy tolerance of 0.2 second. The end time of the vehicle pitch-rate change was 65.404 seconds MET (see figure 62).

(36) Left-Hand Outboard Elevon Actuator Differential Pressure Change

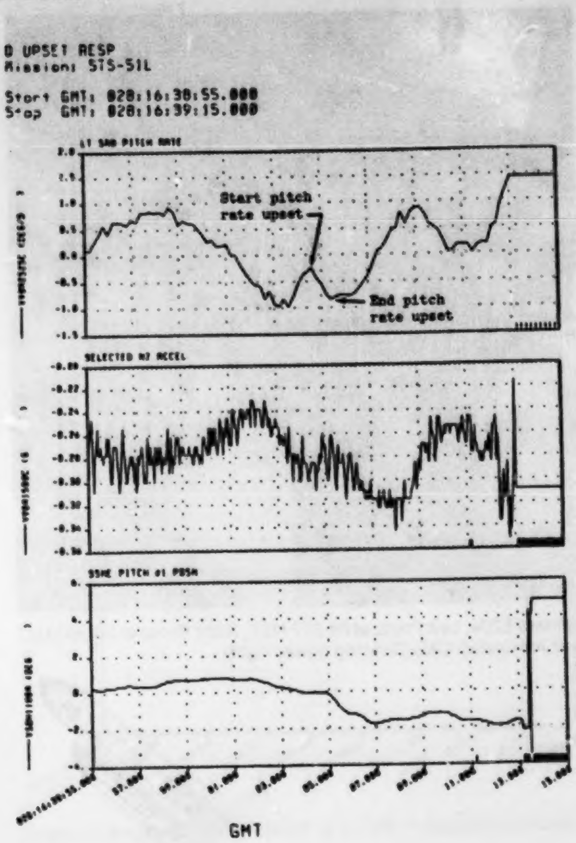
The left-hand outboard elevon actuator differential pressure change was defined using measurement V58P0866C, which is the left-hand outboard elevon primary pressure 1. The first data point indicating the unexpected change in left elevon differential pressure was selected (see figure 61). The measurement has a 12.5-sample/second sample rate with an accuracy tolerance of 0.080 second. The time of the left-hand outboard elevon actuator differential pressure change was 65.524 seconds MET.

FIGURE 61



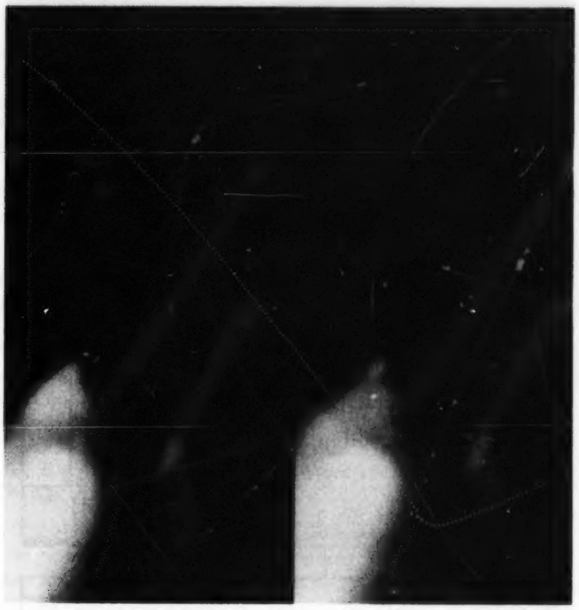
Elevon Actuator Hinge Moment Spike.

FIGURE 62



SRB pitch Rate Change.

FIGURE 63



Camera E204, Left Photo at 64.637 MET, Right Photo at 64.660 MET and Annotated CAD Drawing (lower right)

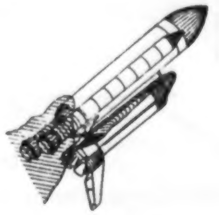
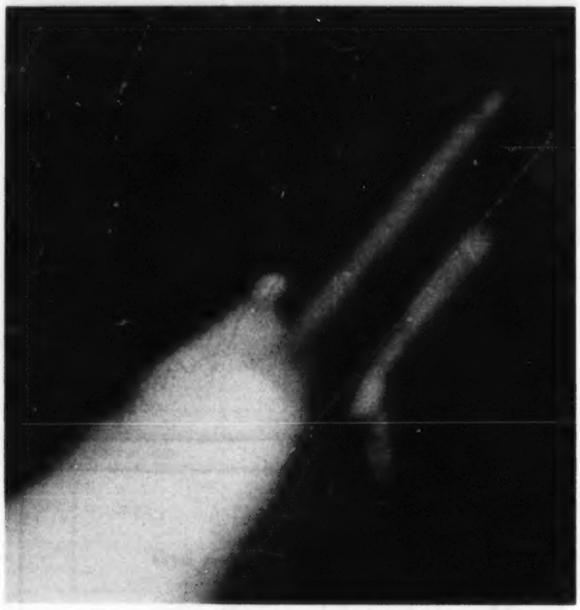
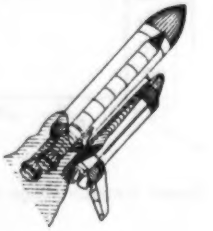


FIGURE 64



Camera E204 at 64.705 MET (above) and Annotated CAD Drawing (right)



(37) Start ET Liquid Hydrogen Ullage Pressure Deviations

Three redundant ullage pressure transducers in the external tank are used for control of the tank pressure and are available via telemetry at 5 samples/second. The start of the change in the tank pressurization rate is identified at 66.764 seconds MET as indicated by measurement T41P1700C (see figure 66).

(38) Start of Right Versus Left SRB Minus Yaw-Rate Divergence

The start of the right SRB versus left SRB minus yaw-rate divergence is defined by measurements V90R2528C for the right SRB yaw rate and V90R2526C for the left SRB yaw rate. The time of the event was selected using the first data sample after the start of the divergence. The measurements have a 5-sample/second sample rate with an accuracy tolerance of 0.2 second. The time of the start of the divergence was 72.201 seconds MET (see figure 67).

(39) Start of Right Versus Left SRB Plus Pitch-Rate Divergence

The start of the right SRB versus left SRB plus pitch-rate divergence is defined by measurement V90R2527C for the right SRB pitch rate and V90R2525C for the left SRB pitch rate. The time of the event was selected using the first data sample after the start of the divergence. The measurements have a 5-sample/second sample rate with an accuracy tolerance of 0.2 second. The time of the divergence was 72.281 seconds MET (see figure 67).

(40) SRB Major High-Rate Actuator Command

The SRB major high-rate actuator command was defined using measurement V79H2111A which is the SRB left hand tilt actuator A driver out command. The measurement has a 25-sample/second sample rate with an accuracy tolerance of 0.040 second. The time of the event was selected using the first data sample reflecting the sudden command change. The time for the SRB major high-rate actuator command was established as 72.476 seconds MET (see figure 68).

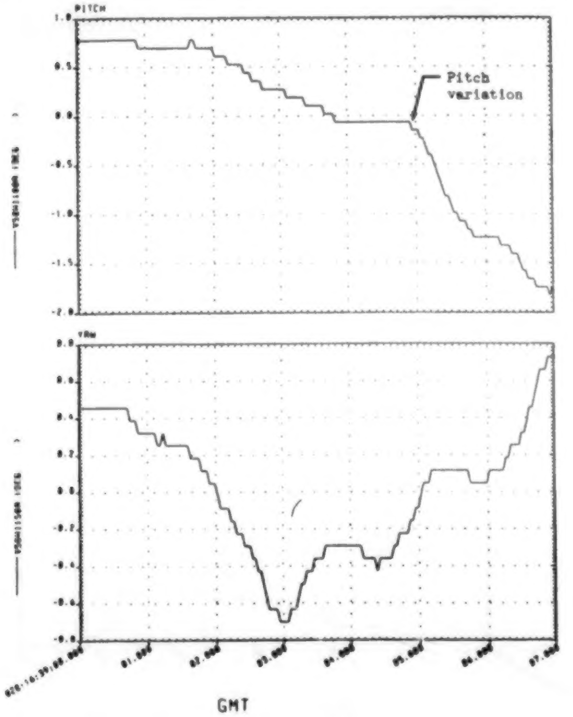
(41) Main Engine Pitch/Roll Gimbal Rate (5 deg/sec)

The time of the main engine pitch/roll (5 deg/sec) gimbal rate was defined using V58H11OOA, which is the MPS engine 1 pitch-actuator position. The first data point indicating the unexpected rate change of 5 deg/sec was selected. The pitch/roll rates were calculated from the position (degrees) of all three engines over the time interval specified. The position change over the time interval was taken from the pitch/yaw curves for each engine (see figure 69). The root-mean-square value of the slope for each of the three engines using the pitch and yaw data was established. These data values were averaged for the three engines to arrive at the 5-deg/sec rate. The measurements used have a 25-sam-

FIGURE 65

ME-1 ACTR POS
Mission: STS-51L

Start GMT: 028:16:39:00.000
Stop GMT: 028:16:39:07.000

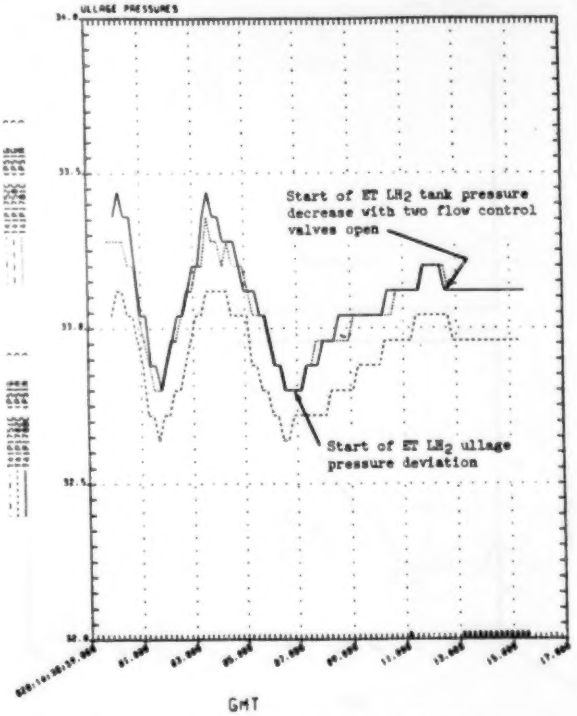


Start of Main Engine Large Pitch Variation.

FIGURE 66

ET ULLAGE PRESSURES
Mission: STS-51L

Start GMT: 028:16:38:59.000
Stop GMT: 028:16:39:17.000



Liquid Hydrogen Ullage Pressure and Tank Pressure Anomalies.

ple/second sample rate with an accuracy tolerance of 0.04 second. The time of the pitch/roll gimbal rate was 72.497 seconds MET.

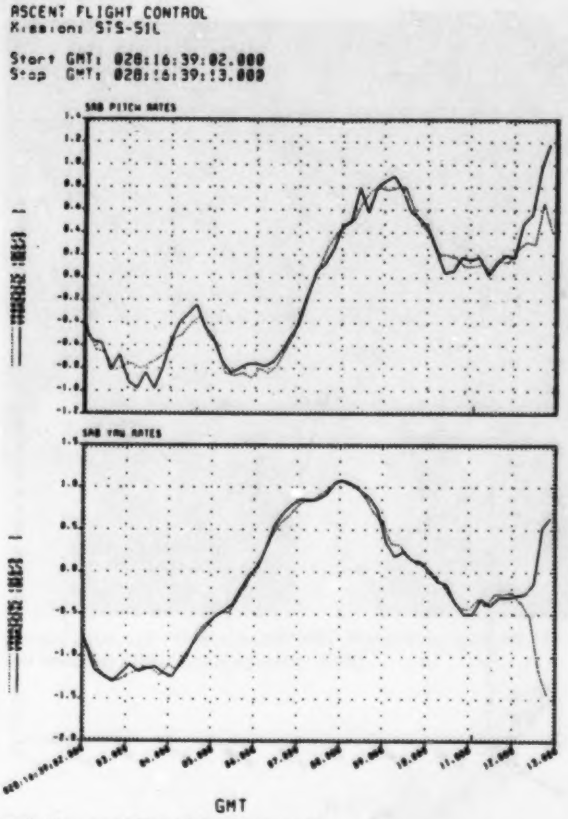
(42) Vehicle Maximum Lateral – Y and + Y Acceleration

The data from the three vehicle accelerometer assemblies was reviewed to determine if any unexpected accelerations were evident. At 72.515 seconds MET, a maximum + Y acceleration was observed on the 25-sample/second measurement V98A1591C. The maximum – Y lateral acceleration was observed at 73.005 seconds MET (see figure 70).

(43) Start of Liquid Hydrogen Tank Pressure Decrease With Two Flow Control Valves Open

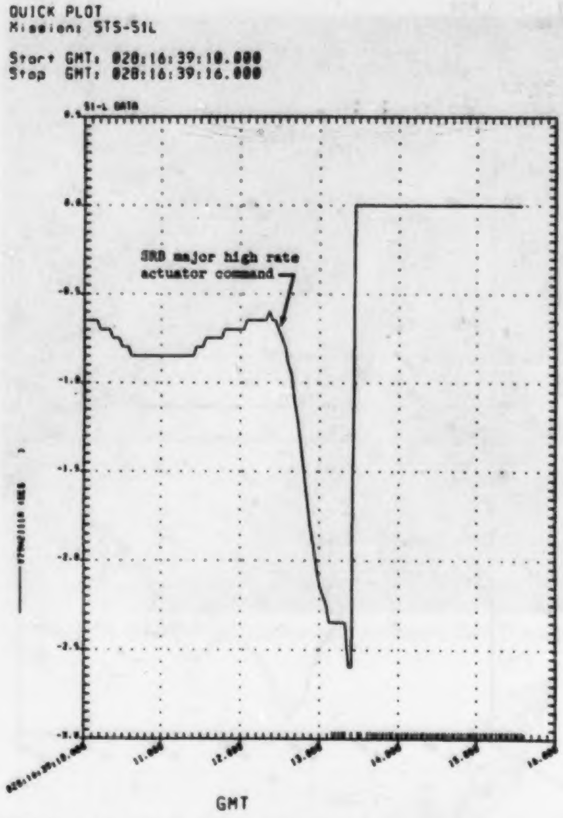
The liquid hydrogen tank pressure decrease with two of the three flow control valves open represents a very large flow from the tank exceeding the repressurization capability. Its onset is identified by the first indication of pressure decrease during an increasing repressurization cycle at 72.564 seconds MET. The first indication occurs on measurement T41P1700C (see figure 66).

FIGURE 67



SRB Yaw and Pitch Rate Divergence.

FIGURE 68



SRB Major High-Rate Actuator Command.

(44) SRB Major High-Rate Actuator Motion

The SRB major high-rate actuator motion was defined using measurement B58H1151C, which is the left position TVC rock actuator. The measurement has a sample rate of 25 samples/second with an accuracy tolerance of 0.04 second. The event time was established by selecting the first data sample reflecting the high actuator rate motion. The selected time for the SRB high-rate actuator motion was 72.564 seconds MET (see figure 71).

(45) Last State Vector Downlinked

The parameters defining the state vector update downlisted from the GPC are:

V95H0185C – X-component of current Shuttle position vector

V95H0186C – Y-component of current Shuttle position vector

V95H0187C – Z-component of current Shuttle Position vector

V95L0190C – X-component of current Shuttle velocity vector

V95L0191C – Y-component of current Shuttle velocity vector

V95L0192C – Z-component of current Shuttle velocity vector

V95W0200C – Time tag associated with current state

These are all 1-sample/second measurements and the time selected was 72.624 seconds MET. This event is a normal ascent event to be used for reference only and corresponds to the last state vector downlisted prior to the incident.

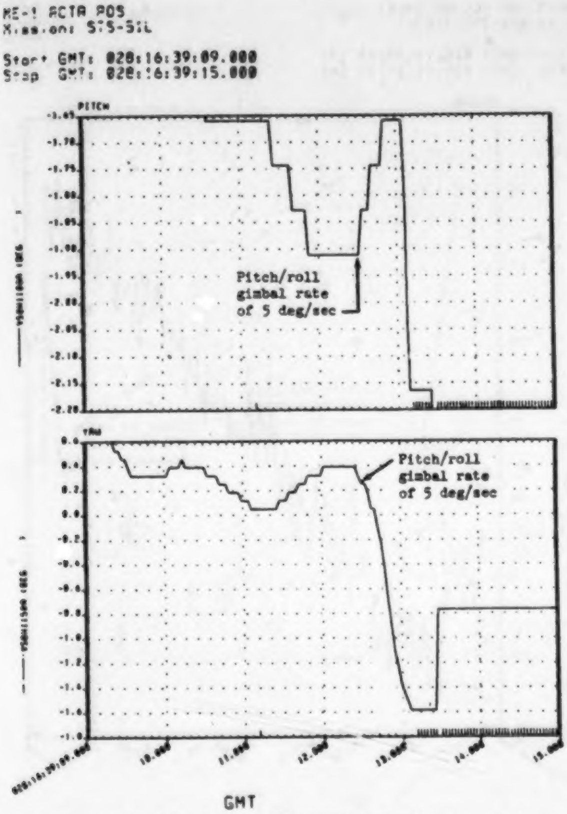
(46) Start of the Sharp MPS Liquid Oxygen Inlet Pressure Drop

The start of the sharp liquid oxygen main propulsion system inlet pressure drop is defined as the first sample of the inlet pressure outside the pressure envelope. The measurement indicating this event is V41P1130C and the time is 72.964 seconds MET (see figure 72).

(47) Orbiter and TDRS Rate Compare at Last TDRS Data

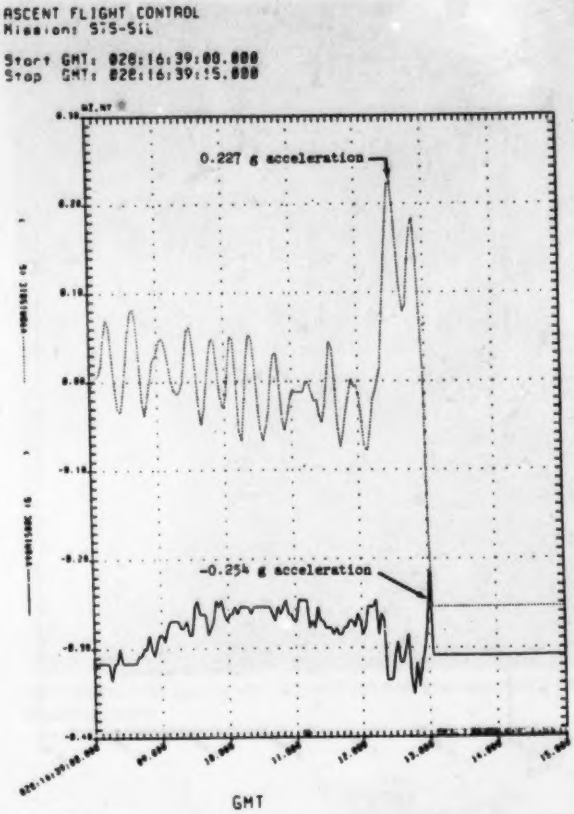
The Orbiter and the tracking and data relay satellite (TDRS) vehicle rates were evaluated from the STS 51-L launch through the last available TDRS data at 73.010 seconds MET. The TDRS rate data were used to overlay the Orbiter rate data for a comparison analysis. The fact that the data were comparable verifies that both vehicles were responding in a similar manner to outside forcing functions. It is concluded from this comparison that the TDRS was properly retained in the Orbiter payload retention devices at the last TDRS data.

FIGURE 69



Main Engine Pitch/Roll Gimbal Rate of 5 deg/sec.

FIGURE 70



Vehicle Maximum Lateral Acceleration.

(48) Right SRB Chamber Pressure 24 psi (Approximately 6 Sigma) Lower Than Left SRB

The right SRB chamber pressure became approximately 6 sigma (24 psi) lower than the left SRB and was defined using measurement B47P1302C for the left SRB chamber pressure and B47P2302C for the right SRB chamber pressure. The measurements used have a 12.5-sample/second sample rate which corresponds to an accuracy tolerance of 0.080 second. The time of the event for each SRB was established by selecting the last valid data sample (see figure 73).

Left SRB (636 psi) 73.044 seconds MET
Right SRB (612 psi)—73.044 seconds MET

(49) Vehicle Maximum E Lateral - Y Acceleration, 0.254g

The maximum - Y acceleration occurred at 73.055 seconds MET as shown on figure 70.

(50) Evidence of Circumferential White Pattern on Left Side of ET Aft Dome (Liquid Hydrogen Tank Failure Near 2058 Ring Frame)

Mission elapsed time: 73.124
Source: Camera E204

This frame (see figure 74) shows fluid streaming from the ET hydrogen tank aft barrel area. The aft barrel failure is suspected to have begun at this time.

(51) First Hint of Vapor at Intertank Stage

Mission elapsed time: 73.137
Source: Camera E207

At 73.137 seconds MET, an arc of vapor occurs along the interface between the ET hydrogen tank and the intertank structure as shown in figure 75. The appearance of the vapor suggests a structural failure of the intertank area.

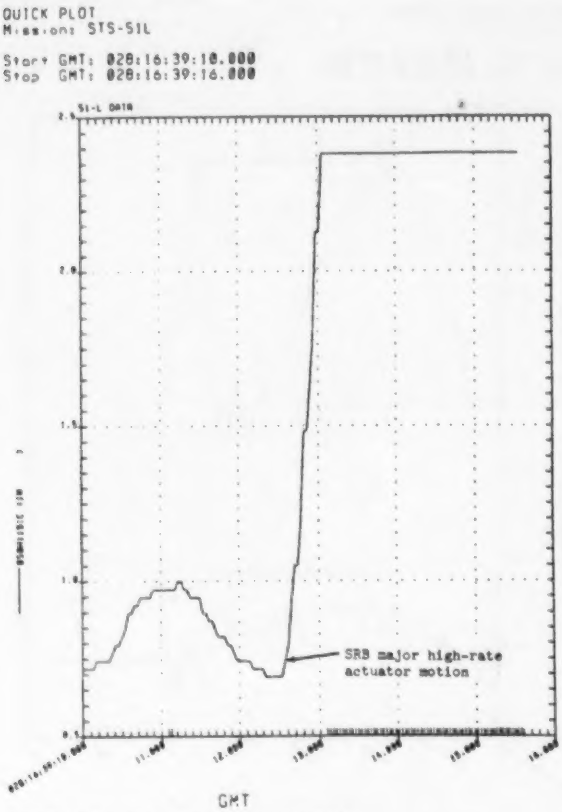
(52) SSME's Responding to Loss of Fuel and Oxidizer Inlet Pressure

At 73.137 seconds MET, a number of SSME parameters were outside the normal operating limits (see figure 76). The specific event chosen to represent this performance deviation is the ME-3 main combustion chamber pressure channel "A" (E41P3016D).

(53) Sudden Cloud Along Side of ET Between Intertank and Aft Dome

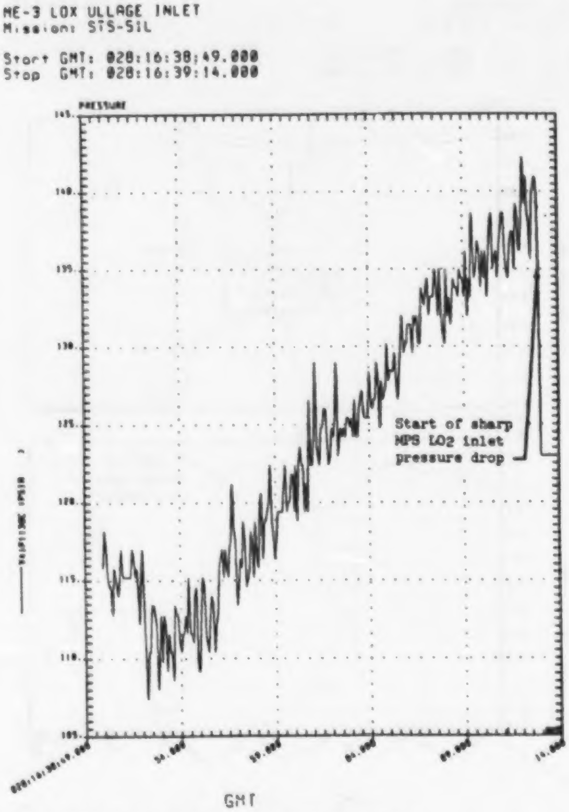
Mission elapsed time: 73.162
Source: Camera E207

FIGURE 71



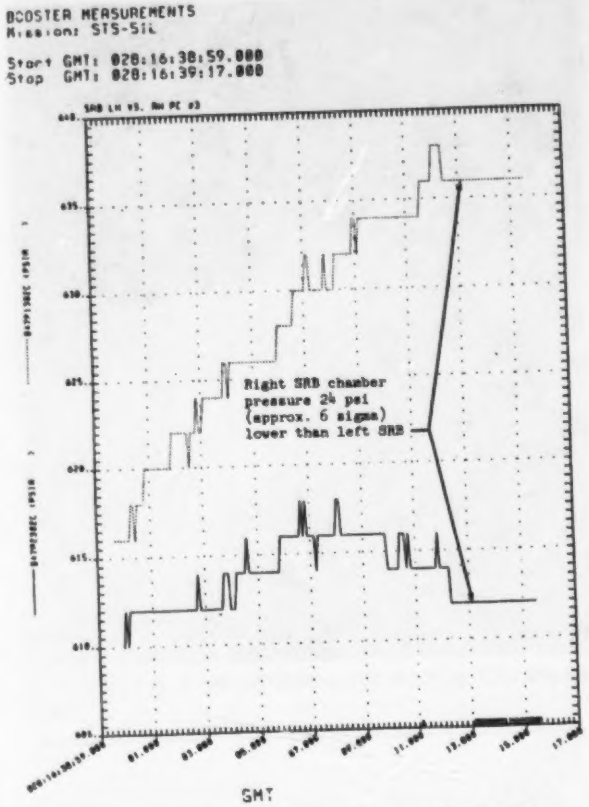
1 SRB Major High-Rate Actuator Motion.

FIGURE 72



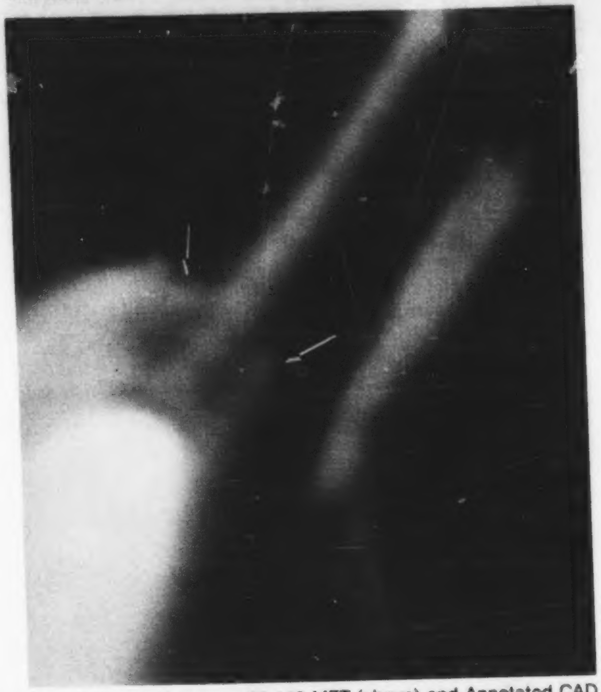
Sharp MPS Liquid Oxygen Inlet Pressure Drop.

FIGURE 73



Right SRB Versus Left SRB Chamber Pressure Difference.

FIGURE 74



ROTI Camera at approx. 73.140 MET (above) and Annotated CAD Drawing (Right)

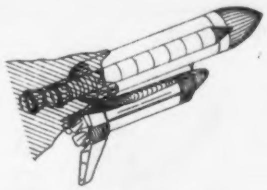
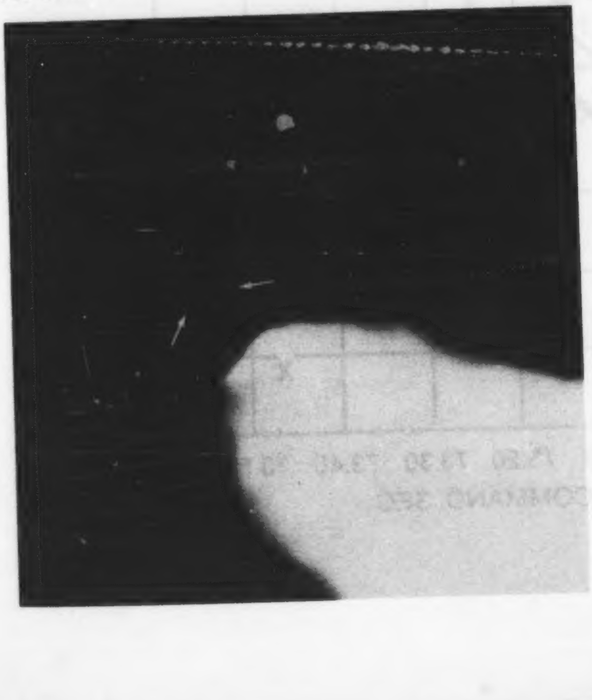
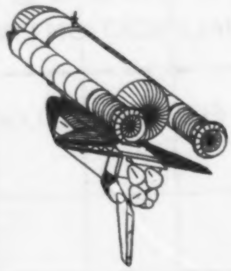


FIGURE 75





Camera E207 at 73.137 MET (above) and Annotated CAD Drawing (right).

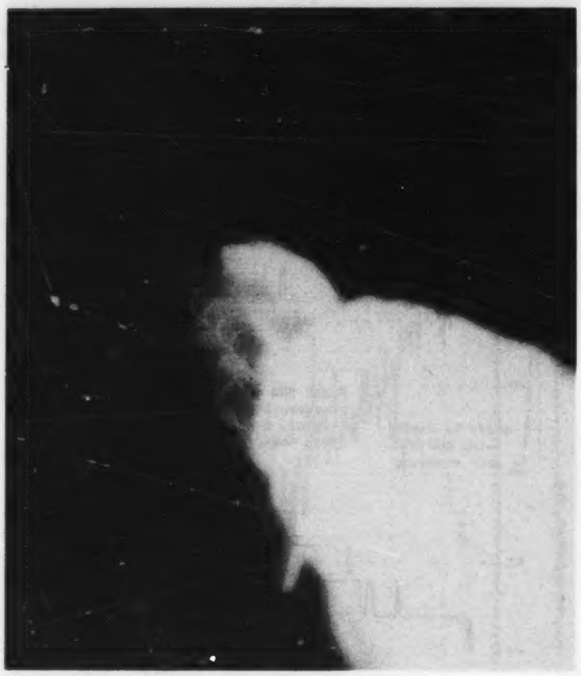
After the initial onset of vapor from the intertank area, the vapor cloud increases in intensity and volume, flowing alongside the ET between the intertank and the aft dome (see figure 77).

(54) Flash from Region Between Orbiter and ET Liquid Hydrogen

Mission elapsed time: 73.191
Source: Camera E204

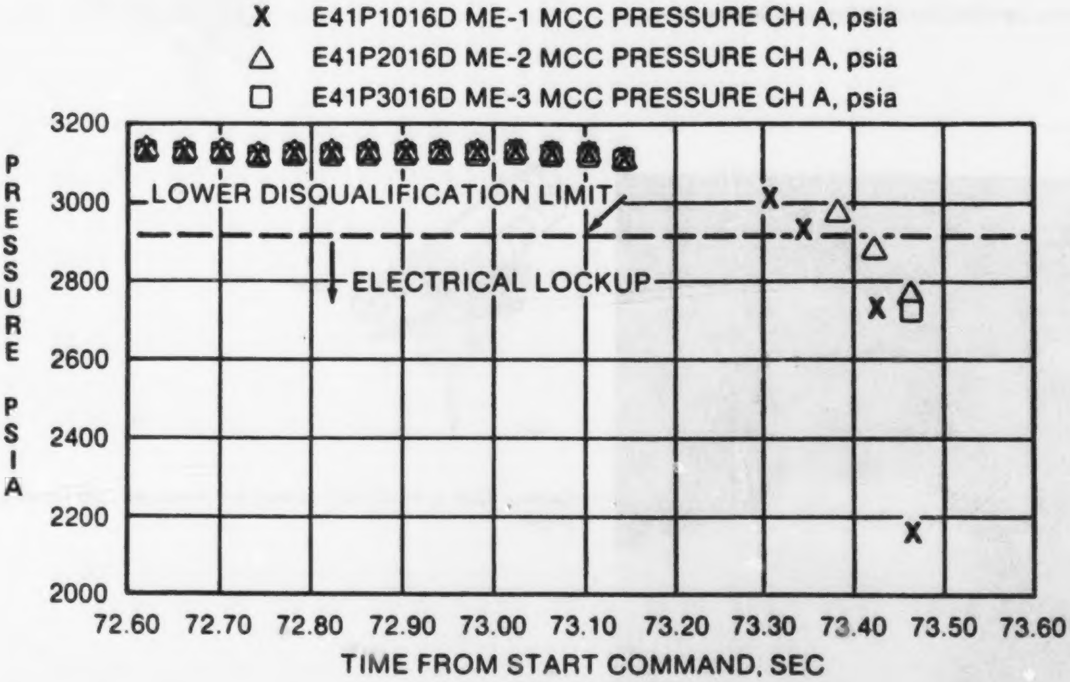
Analysis of film from camera E204 and the NASA Select video shows a flash from the region between the Orbiter and the ET liquid hydrogen tank with the apparent center (based on CAD analysis) at the Orbiter midbody (see figure 78). The view from camera E207 showing the right side of the vehicle indicates a significant area of radiance between the aft dome and the intertank. The flash seen from viewing the left side of the vehicle is a probable result of the forward propagation and enriched burning of the SRB exhaust products in the separated flow region caused by the anomalous SRB plume and the release of hydrogen from the aft liquid hydrogen tank failure.

FIGURE 77



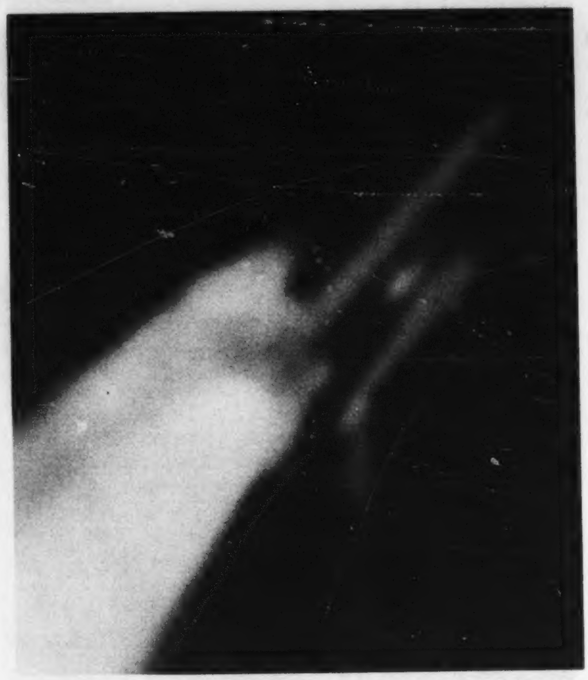
Camera E207 at 73.162 MET with CAD Inlay.

FIGURE 76



SSME Response to Loss of Fuel and Oxidizer Inlet Pressure.

FIGURE 78



Camera E204 at 73.191 MET (Above) and Annotated CAD Drawing (right).

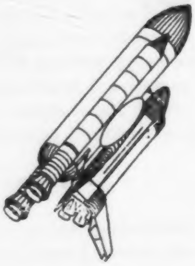
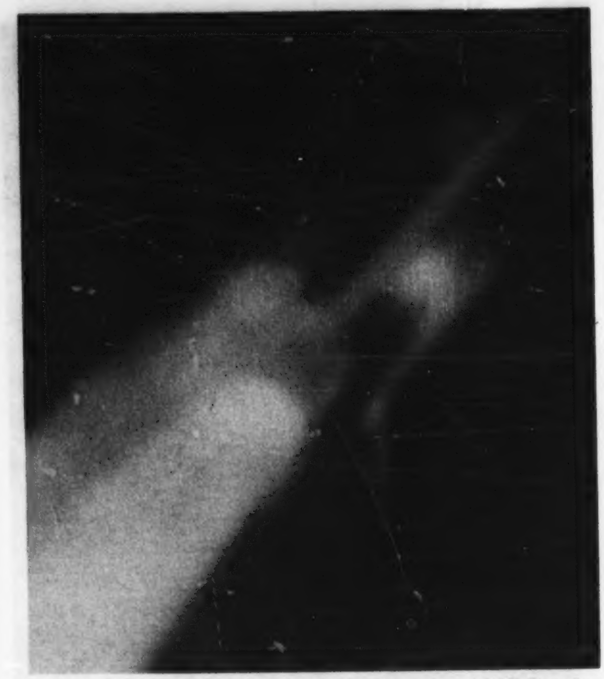
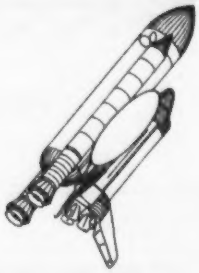
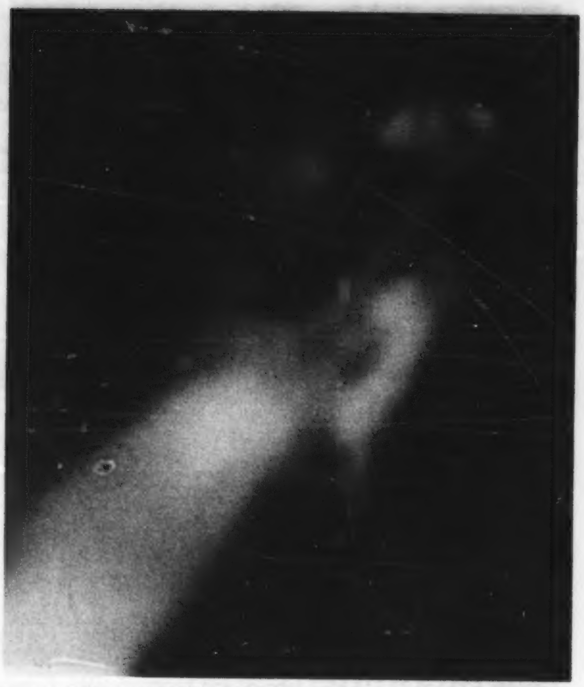


FIGURE 79

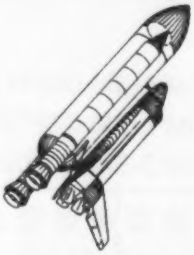


Camera E204 at 73.213 MET (above) and Annotated CAD Drawing (right).





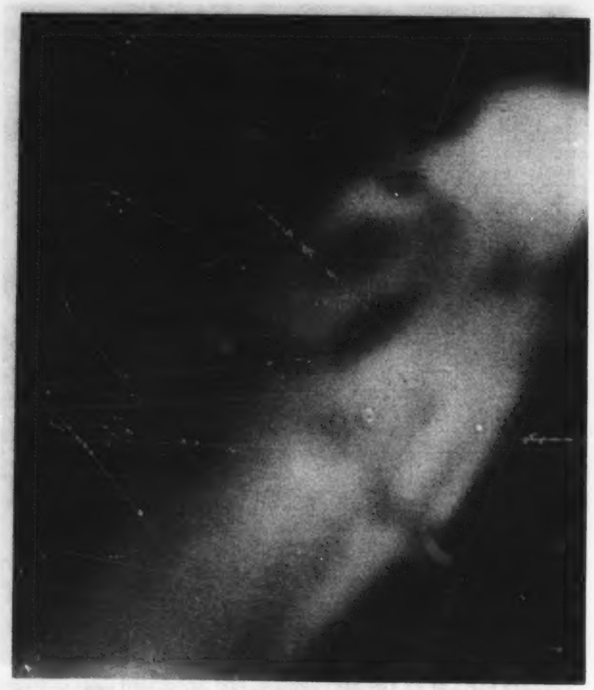
Camera E204 at 73.282 MET (above) and Annotated CAD Drawing (right).



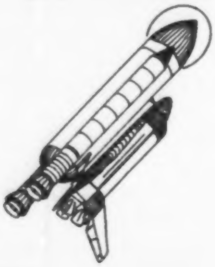
(55) Flash Near SRB Forward Attach (Intertank) and Brightening of Flash Between Orbiter and ET

Mission elapsed time: 73.213
Source: Camera E204

Camera E204 viewing the left side of the vehicle indicates a flash near the SRB forward attach (intertank) area and a brighten ing of the flash between the Orbiter and the ET (see figure 79). A view of the right side of the vehicle from camera E207 shows a significant increase in the volume of the recirculated hydrogen-enriched SRB exhaust products as a result of freestream flow blockage induced by the anomalous SRB plume and the rapidly increasing release of hydrogen from the aft liquid hydrogen tank failure. The flash near the SRB forward attach area is potentially the circumferential propagation of the radiant SRB exhaust products due to aerodynamic effects and structural failure of the intertank area.



Camera E204 at 73.327 MET (above) and Annotated CAD Drawing (right)



(56) First Indication of Intense White Flash at SRB Forward Attach Point

Mission elapsed time: 73.282
Source: Camera E204

This view of the left side (figure 80) of the vehicle shows the start of the major structural failure of the liquid oxygen tank. A small intense flash occurs just ahead of the SRB forward attach and grows into a large, extremely bright spherical shaped flash in succeeding frames.

(57) Greatly Increased Intensity of White Flash

Mission elapsed time: 73.327 Source: Camera E204

The white flash increases in intensity as it grows to its maximum size (see figure 81) and then decreases over the next 100 or so milliseconds. This intense white flash is attributed to the failure of the liquid oxygen aft dome/intertank.

(58) Start RCS Thrust Chamber Pressure Fluctuations

Chamber pressure measurements for all 44 thrusters were reviewed throughout the flight interval. Fluctuations were seen on a preponderance of primary thruster chamber pressures. The first of these fluctuations occurs on V42P1552A at 73.377 seconds MET. This data is from one of two forward down-firing Orbiter thrusters (see figure 82).

(59) SSME's Approaching High-Pressure Fuel Turbopump Discharge Temperature Redline

The high-pressure fuel turbopump (HPFTP) discharge temperature for all SSME's was approaching the temperature redline at 73.399 seconds MET (see figure 83). The measurement chosen to define this event was main engine 2 HPFTP discharge temperature (E41T2010D). The point prior to the engine redline temperature was chosen.

(60) SSME-1 in Shutdown – HPFTP Discharge Temperature Redline Exceeded

The HPFTP discharge temperature on main engine 1 (ME-1) has exceeded its upper limit and met the requirements of the main engine (ME) controller for an engine shutdown. The shutdown event is identified as ME-1 Phase-In-Effect (E41J1512B) which occurred at 73.543 seconds MET (see figure 83). The event is confirmed by a preponderance of ME-1 parameters.

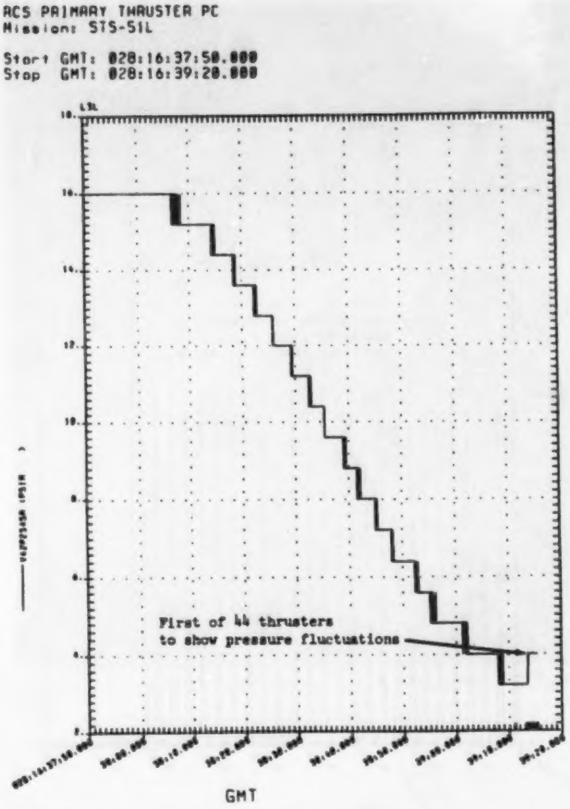
(61) Last Validated Telemetry Measurements – L3L RCS Thruster Chamber Pressure

Review of the reaction control system (RCS) thruster chamber pressure data has established that, during the last 0.600 second prior to the incident, several synchronization losses were evident. The RCS chamber pressures were fluctuating for the most part from 0.8 to 1.6 psia. These data are considered to be verifiable data points with the last data point being selected from measurement V42P2545A, which is the L3L RCS thruster chamber pressure. The L3L chamber pressure measurement is a 25 sample/second measurement with an accuracy tolerance of 0.04 second. The time of the last data point was defined as 73.615 seconds

(62) Last Validated Telemetry Measurements – APU 1 Gas Generator Chamber Pressure

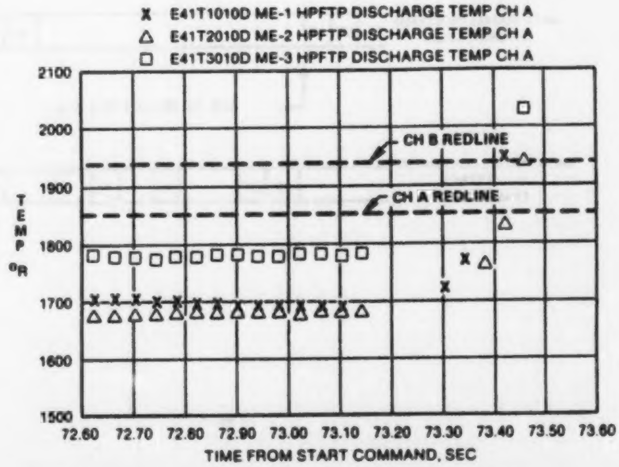
Review of the high-sample-rate Orbiter measurements during the last 0.600 second prior to the incident indicated several synchronization losses. Measurement V46P0120A, auxiliary power unit (APU) 1 gas generator chamber pressure, was one of those measurements reviewed and provided the last validated data sample. The measurement was validated by comparing the last data sample value with preceding data sample values versus the normal operating values. The gas generator chamber pressure on APU 1 is a 100-sample/second measurement with an accuracy tolerance of 0.01 second. The time of the last validated APU 1 gas generator chamber pressure measurement was 73.618 seconds MET (see figure 84).

FIGURE 82



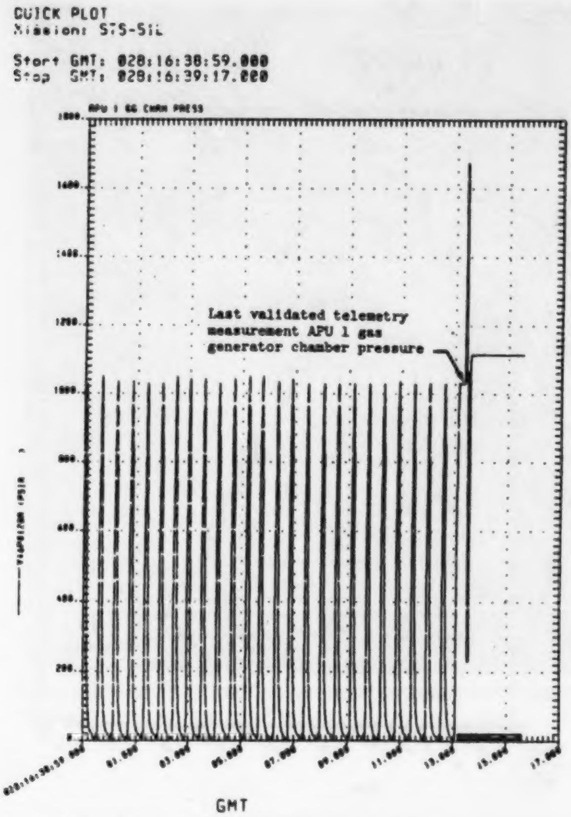
RCS Thruster Chamber Pressure Fluctuations.

FIGURE 83



SSME's Approaching Temperature Redline and Shutdown.

FIGURE 84



APU 1 Gas Generator Chamber Pressure.

(63) End of Last Data Frame with Valid Synchronization and Frame Count

The quality of the last 450 milliseconds of Orbiter data was deteriorating, most probably as a result of data transmission through an expanding gas cloud emanating from the disintegrating vehicle.

The status of the data processed during this time interval on an Orbiter minor-frame-by-frame basis is presented in figure 85. Each frame of Orbiter data is 10 milliseconds in length. Near the beginning of each frame following frame synchronization, a data word appears listing the status of a counter in the telemetry system which indexes one count each 10 milliseconds. A raw data dump was utilized to observe the synchronization and frame count for the last data frame. This frame ends at 73.631 seconds MET.

(64) Last RF Signal from Orbiter

This event was defined by processing on a high-speed strip-chart recorder the phase-modulated (PM) S-band carrier raw signal (2287.5 mHz SSME data) as recorded at the MILA ground station. The end of the RF signal is marked by a sharp change in character of the video signature and abrupt shift in signal level. This change occurs at 74.130 seconds MET when the FM signal ends.

The event has been verified by correlation with the ground-recorded automatic gain control (AGC) signal from the S-band FM receiver.

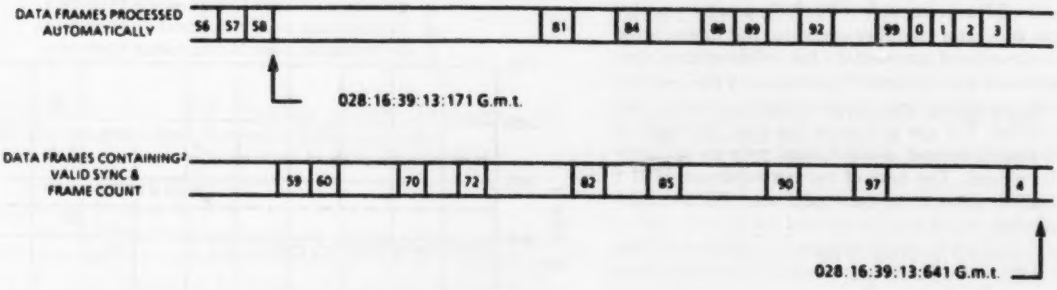
The data tape from the Ponce de Leon station was also processed as described and the signal as received at this ground station ended within 2 milliseconds of the time selected.

(65) Bright Flash in Vicinity of Orbiter Nose

Mission elapsed time: 74.587
Source: Camera E204

A bright flash in the vicinity of the Orbiter nose is evident after the Orbiter emerges from the ET vapor cloud as seen on figure 86. A distinctive reddish brown cloud is evident and suggests that the forward RCS propellant lines failed and that overboard spillage of the RCS oxidizer and fuel resulted in an abrupt hypergolic reaction.

FIGURE 85



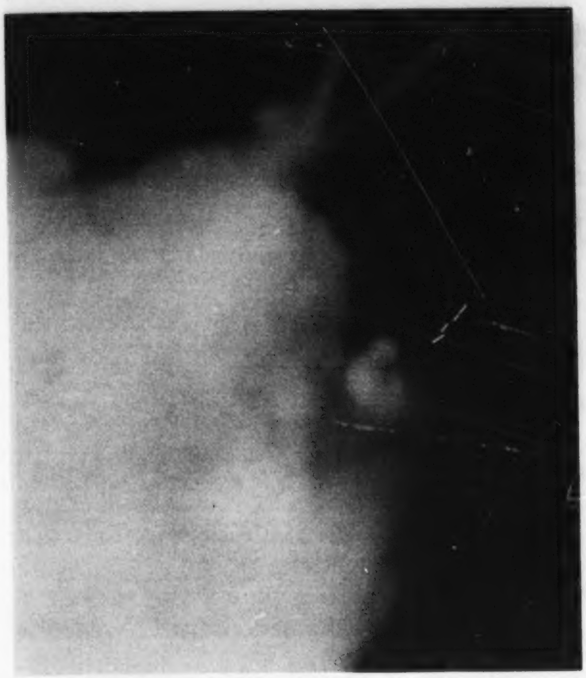
NOTES:

[1] EACH DATA FRAME IS .010 SECONDS LONG.

[2] DATA FROM THESE FRAMES WERE EXTRACTED MANUALLY AND VALIDATED AS DESCRIBED IN PARAGRAPH ENTITLED "END OF LAST DATA FRAME WITH VALID SYNCHRONIZATION AND FRAME COUNT".

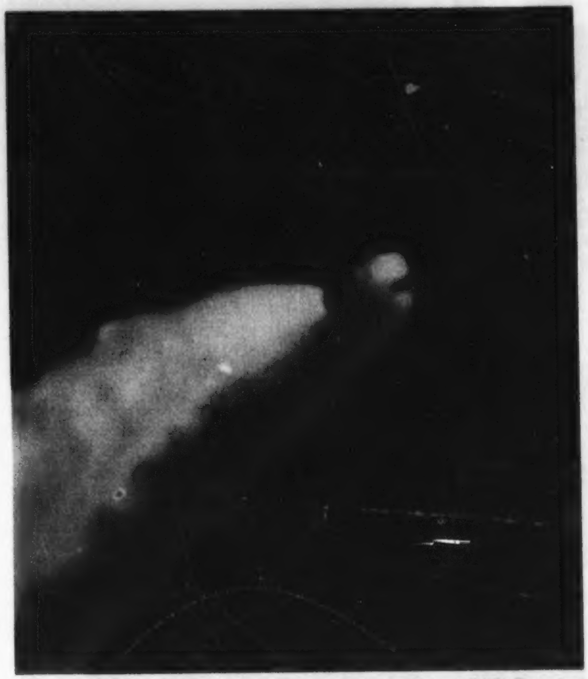
Last Recoverable Data Frames by Operational Instrumentation Minor Frame Number.

FIGURE 86



Camera E204 at 74.587 MET

FIGURE 87



Camera E207 at 76.437 MET (above) and Annotated CAD Drawing (right)

Photograph taken at 77.113 MET.

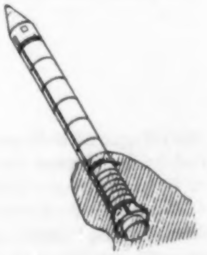
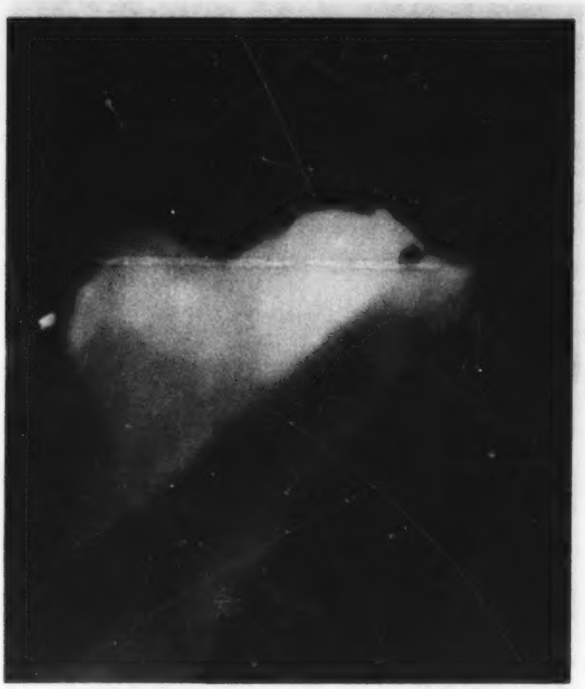
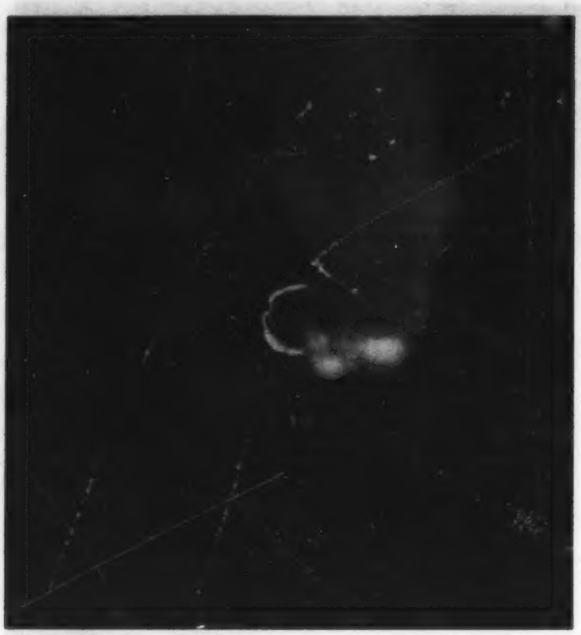


FIGURE 88



Camera E206 at 76.475 MET
Photograph taken at 77.888 MET.

FIGURE 89



Camera E202 at 110.250 MET
Photograph taken at 110.283 MET.

(66) Right SRB Nose Cap Separation/Chute Deployment
Mission elapsed time: 76.437
Source: Camera E207

Figure 87 shows the nose cap separating from the SRB. At 76.686 seconds MET, the drogue chute starts to deploy approximately parallel to the SRB axis as seen in figure 88.

(67) Right SRB Range Safety Systems Destruct
Mission elapsed time: 110.250
Source: Camera E202

Range safety destruct of the right SRB is evident in figure 89. This time correlates with the time at which the destruct signal was sent.

(68) Left SRB Range Safety Systems Destruct
Mission elapsed time: 110.252
Source: Camera E230

Range safety destruct of the left SRB is evident in figure 90.

3. *Evaluation Data Source And Telemetry Data Processing*

The engineering telemetry data reviewed by the Orbiter systems personnel were generated from the data recorded as received at the MILA ground station. Initially, data were processed from tapes produced by the network interface processor (NIP) at Mission Control Center (MCC) from the data transmitted to Houston in real time. The real-time data received initially at MCC were also supplied to the trend monitoring system (TMS) facility which provided data for a quick-look data scan at a reduced sample rate. Subsequently, the MILA-recorded data was replayed into the MCC from the MILA site with all data quality validation criteria removed in order to recover the maximum quantity of data during the final fractions of seconds when the data were deteriorating. NIP tapes of these data were processed into final data products (i.e., plots, tabulations, strip charts) by both the Orbiter Data Reduction Complex (ODRC) and MASSCOMP facilities and provided to the system analysts.

Both the MILA and PDL raw data tapes were later sent to Houston and examined to verify that all available data had been processed. A raw data dump from the MILA data tape was provided to enable the last 450 milliseconds of data to be viewed during the time of the deteriorating data. The last recoverable data frames (by operational instrumentation minor frame number) processed automatically were 56, 57, 58, 81, 84, 88, 89, 92, 99, 0, 1, 2, 3. Each data frame is 0.010 second long. The last recoverable data frames containing valid synchronization and frame count were 59, 60, 70, 72, 82, 85, 90, 97, 4. Data from these frames were extracted manually and validated as described in event (63). The first break in the automatically processed data frames occurred after frame 58 at 73.161 seconds MET. Frame 4, the last frame containing valid synchronization and frame count, ended at 73.631 seconds MET (figure 85).

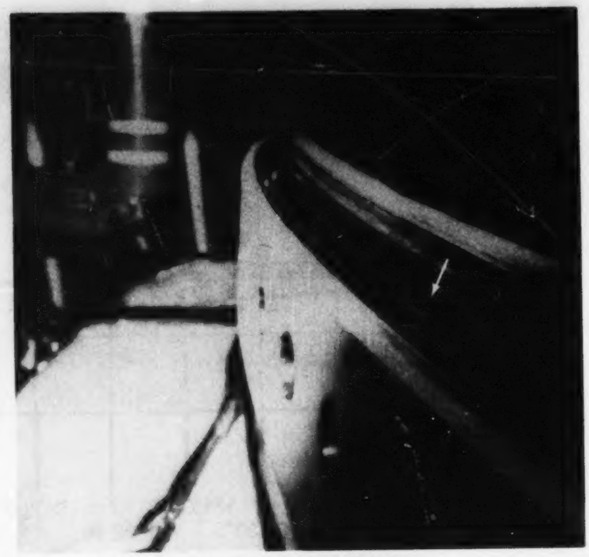
All data processed through the ODRC and MASSCOMP facilities have been time corrected for delays within the telemetry system with the exception of GPC data. The GPC data staleness has been verified to be within the sample period of the measurement for all measurement sampled at higher than 1 sample/second.

The events defined by the 1-sample/second measurement listed in the official timeline have been verified to have occurred within one sample period.

FIGURE 90

Camera E230 at 110.252 MET.

FIGURE 91



Closeout Photo Showing Dark Space and Streaks.

Special Analyses

This section of the report provides the results of specific photographic analysis which were accomplished during the STS 51-L incident investigation.

1. *Closeout Photo Analyses—STS 51-L Right-Hand Aft Field Joint*

A special analysis effort was undertaken to use digital photographic enhancement methods to extract as much information as possible from the closeout photos taken during mating of the STS 51-L aft-center segment to the aft segment on the right-hand SRB.

After installation of the two O-rings in the clevis, approximately 12 closeout photographs were taken around the joint, showing the primary and secondary O-rings and other features of the clevis. These pictures were examined to determine if any damaged or defective areas existed in the O-rings or if any contamination existed on the O-rings. The pictures for the right-hand aft field joint were not of engineering quality and little could be determined by direct inspection of the prints.

However, an interesting thickening of the dark space between the upper surface of the secondary O-ring and the lower edge of the land was noted, together with notable streaks in the same area (figure 91). This print was digitized and enhanced, and the thickening of the dark space was measured. Results indicated a gradual thickening of about 0.015 inch and a decrease to about 0.006 inch within about 0.5 inch length (figure 92). This data suggested a possible O-ring defect.

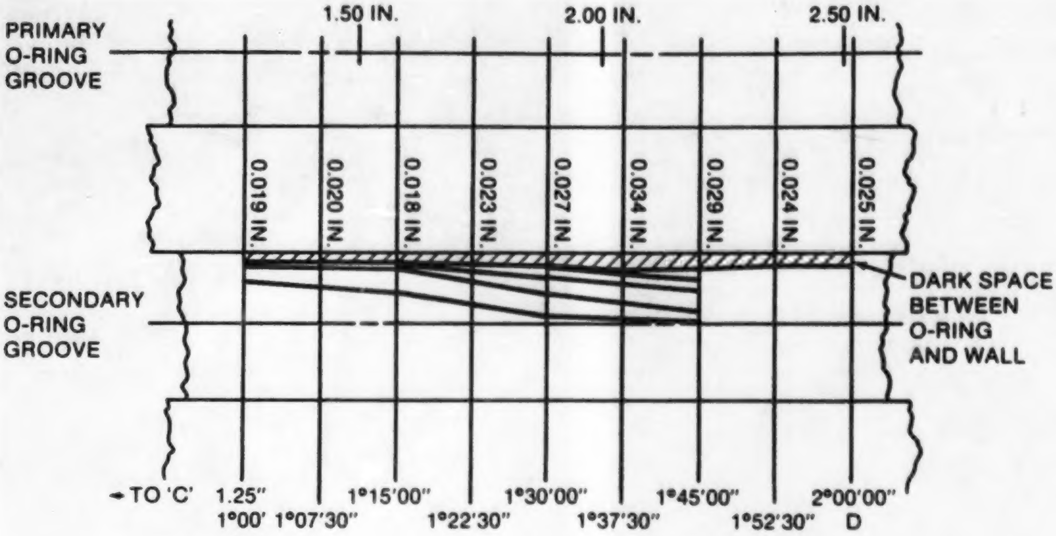
The original negative was obtained and digitized and enhanced. Much more detail about the gradual thickening of the dark space was present in the original negative. The upper edge of the dark space was now found to contain two abrupt discontinuities which are faithfully mapped to the lower edge of the dark space, indicating that what was observed was a shadow of irregularities in the grease on the lower edge of the land (figure 93).

A project was also started to see if the original picture could be replicated with an O-ring defect of the size suggested by the thickening of the dark area. O-rings were distressed to match the suggested defect, and the photographic arrangement was reproduced. The O-rings were greased and installed in a portion of a clevis joint, in accordance with normal field joint installation procedures. The defects were obvious without enhancement of the photograph (figures 94 and 95).

Questions had been voiced regarding the small streaks seen in the same area, both on the O-ring and on the land. It was believed that such small structures could not be formed in the grease while following the standard field joint O-ring installation procedures (surgically gloved hands, no use of the brush after the grooves were greased, etc.). Such small-scale detail was easily generated with the surgically gloved hand. Ridges of 0.005 inch were readily made, and, with heavier coats of grease, grooves or ridges of 0.020 inch characteristic height were formed (figure 96).

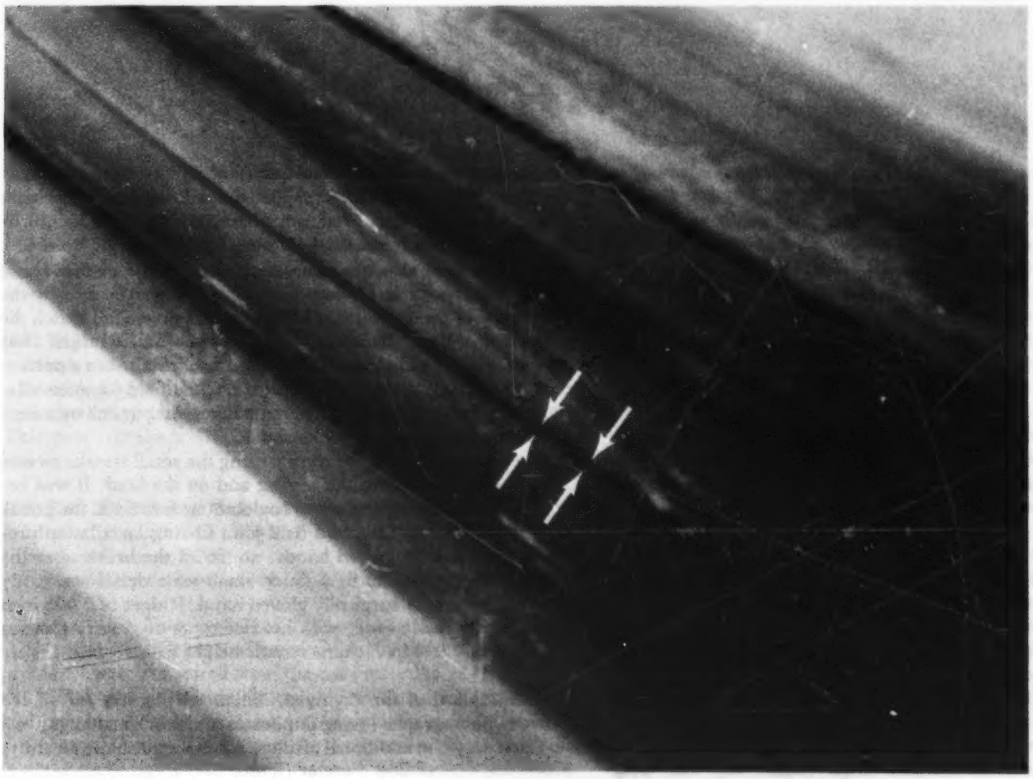
Examination of the digitized, enhanced pictures for all the closeout photographs (using duplicates of the original negatives) revealed only one additional artifact, a horseshoe-shaped feature, somewhat resembling a crater (figure 97). Reasonable replicas of this feature were constructed in the grease patterns using normal procedures as detailed above (figure 98). Therefore, this feature was considered to be a grease pattern, not a contamination item.

FIGURE 92


PRIMARY O-RING GROOVE
1.50 IN.
2.00 IN.
2.50 IN.
0.019 IN.
0.020 IN.
0.018 IN.
0.023 IN.
0.027 IN.
0.034 IN.
0.029 IN.
0.024 IN.
0.025 IN.
SECONDARY O-RING GROOVE
DARK SPACE BETWEEN O-RING AND WALL
TO 'C'
1.25"
1°00'
1°07'30"
1°15'00"
1°22'30"
1°30'00"
1°37'30"
1°45'00"
1°52'30"
2°00'00"
D

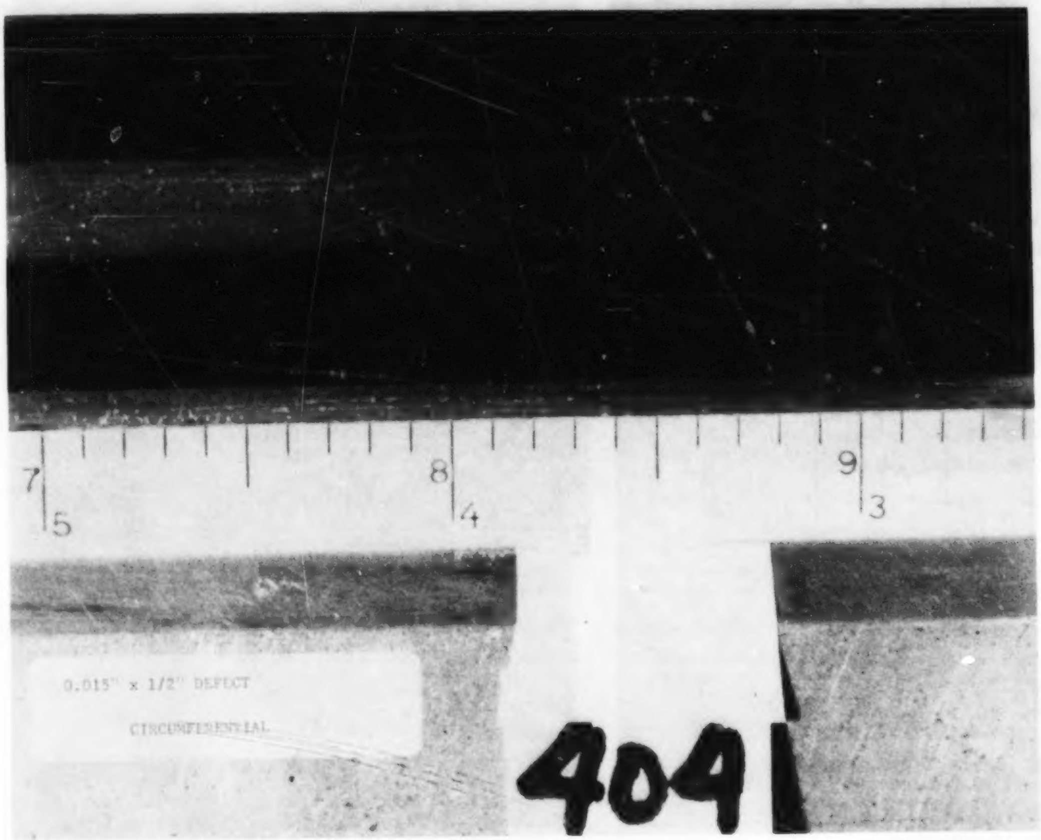
Mensuration Data about Dark Space Between O-Ring and Wall.

FIGURE 93



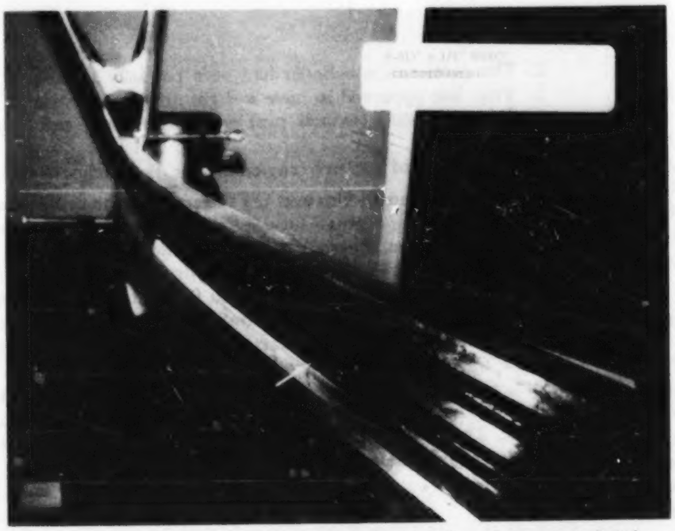
Irregularities on Edges of Dark Band (enhancement from original negative).

FIGURE 94


7
8
9
5
4
3
0.015" x 1/2" DEFECT
CIRCUMFERENTIAL
4041

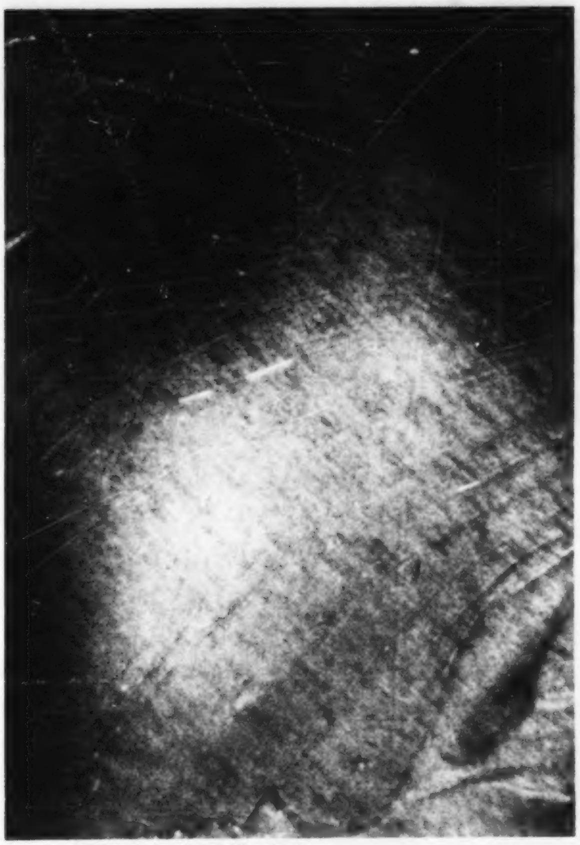
Greased 0.015-Inch by 0.5-Inch Circumferential Defect in Groove.

FIGURE 95



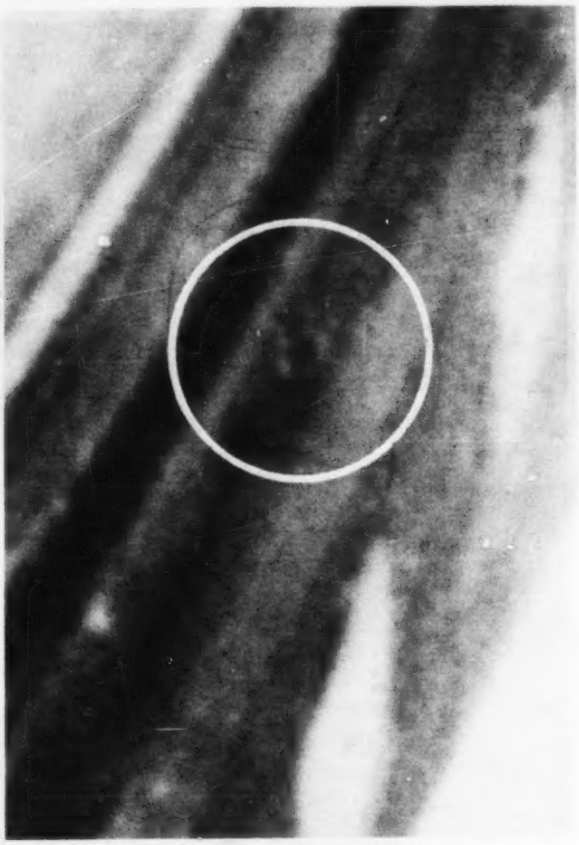
0.015-Inch by 0.5-Inch Circumferential Defect (replica of closeout photo).

FIGURE 96



Grease Patterns (5x Magnification).

FIGURE 97



Horseshoe-Shaped Crate (From Enhanced Photo).

2. *Vehicle "Twang"*

In support of the investigation of the vehicle response, to SSME ignition, the so-called vehicle "twang," a special analysis was conducted to measure the deflection of the ET nose tip. This tip deflection was measured from film E79 using the motion analyzer. Figure 99 shows the measured tip deflection for STS 51-L, and figure 100 compares this tip deflection with those measured on the last two launches of the Challenger. No anomalous motions are observed during this analysis.

3. *Pad Photographic Results*

The following are the significant results as determined from review of the pad photographic and video systems.

a. *Facility Hydrogen Vent Arm Retract Latchback Failure*

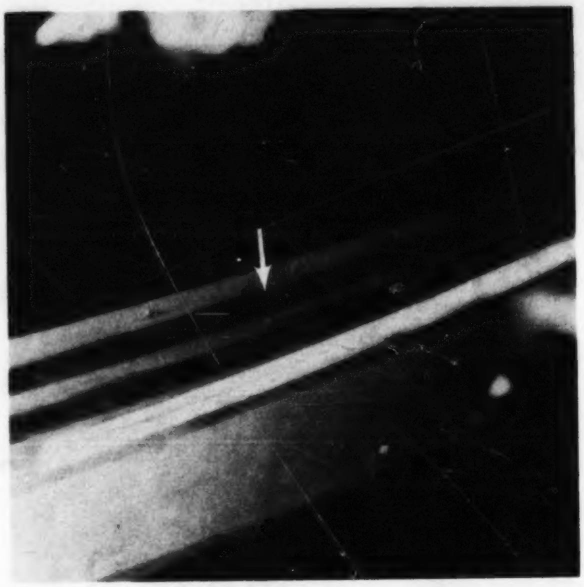
Launch film from camera 41 shows that the gaseous hydrogen vent arm does not firmly latch when retracting at T-0 (see figure 101). Postlaunch inspections confirmed the latch failure (see figure 102). The inspections of the latch system also revealed no immediate explanation as to why the arm and ground umbilical carrier plate (GUCP) failed to latch back. Significant inspection findings are as follows:

1. The vent arm was hanging slightly off centerline (approximately 2 inches south).
2. The deceleration cylinder had been partially stroked.
3. Vent line appeared to have a slight amount of twist.
4. Trunnion stud (launch pin) was broken and nut was missing.
5. Static lanyard was not tangled around the latchback bar.

Review of all launch film and OTV data shows that the arm does not escape the capture envelope that the facility structure provides. Moreover, this review gave no indication of the vehicle passing more closely to the gaseous hydrogen vent arm than observed on previous launches. Launch film data excludes two cameras that are normally dedicated to view the latchback mechanism since the facility modifications had not been completed to allow for installation of these cameras.

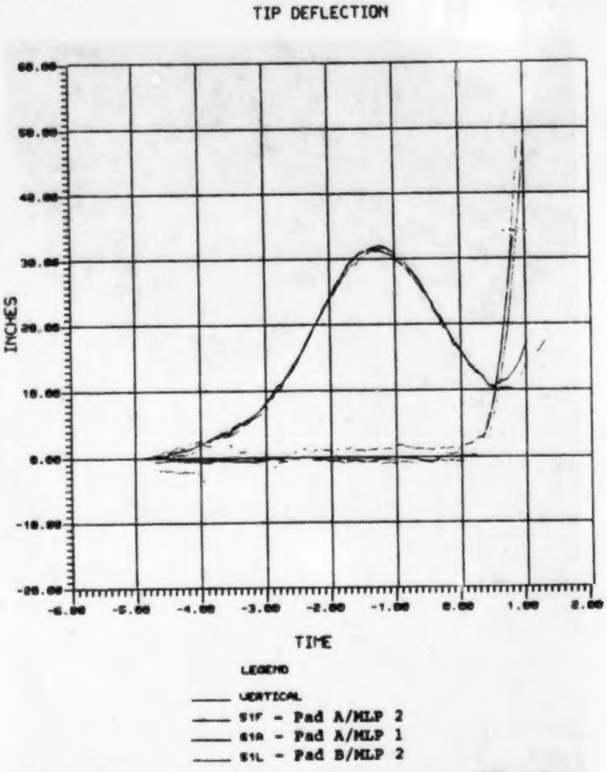
Sufficient data exists to exclude facility hydrogen vent arm retract latchback failure as a contributing factor to the STS 51-L incident. There is insufficient OTV/film data to define the cause of the latchback failure exactly.

FIGURE 98



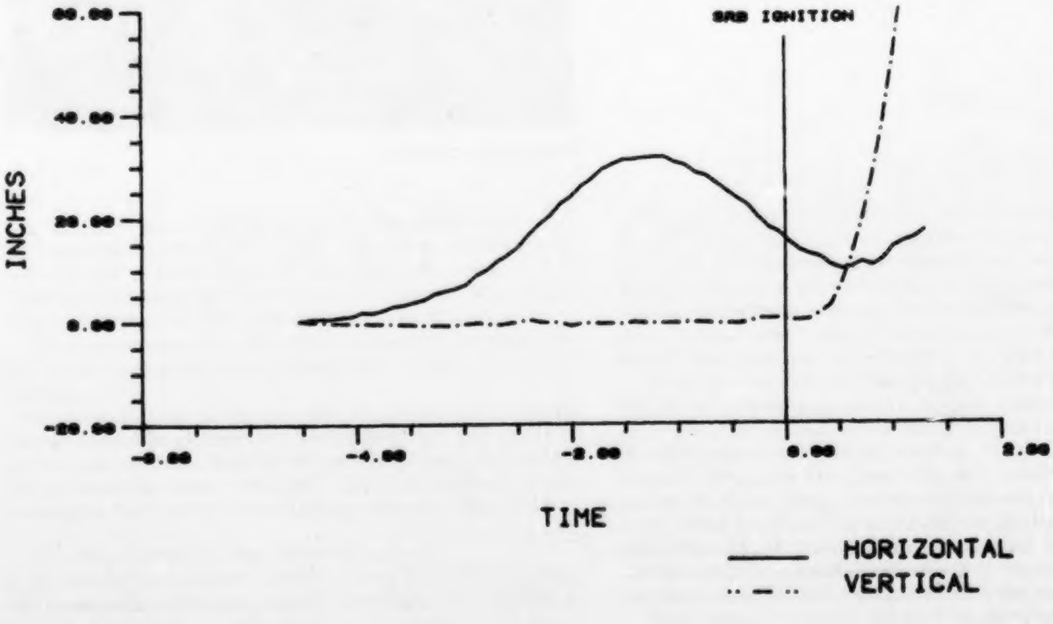
Replica of Horseshoe-Shaped Crater.

FIGURE 100



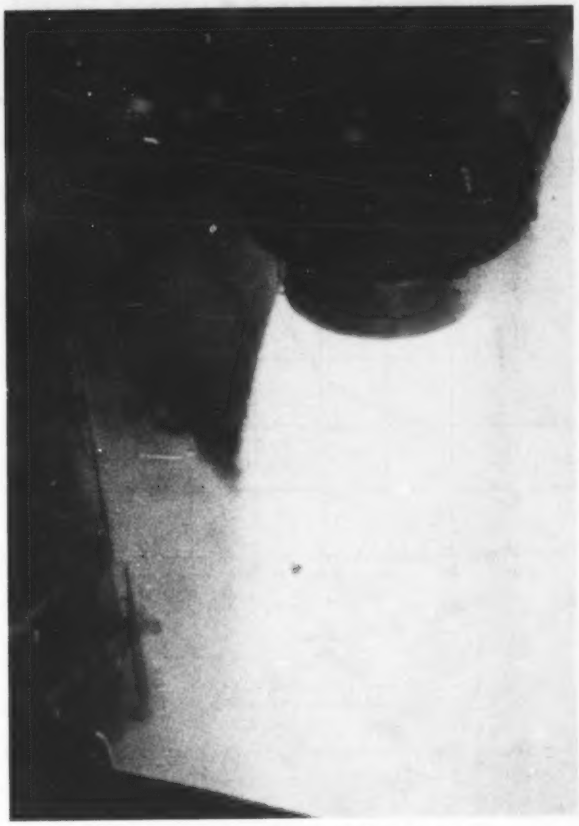
STS 51-L Tip Deflection Versus Tip Deflections from STS 51-F and STS 61-A.

FIGURE 99



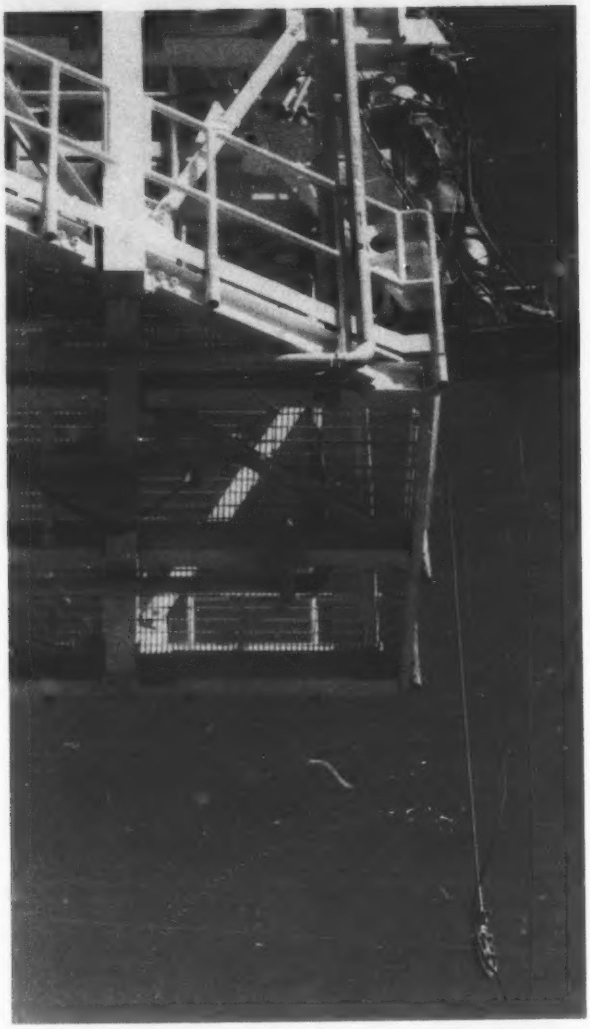
STS 51-L Tip Deflection.

FIGURE 101



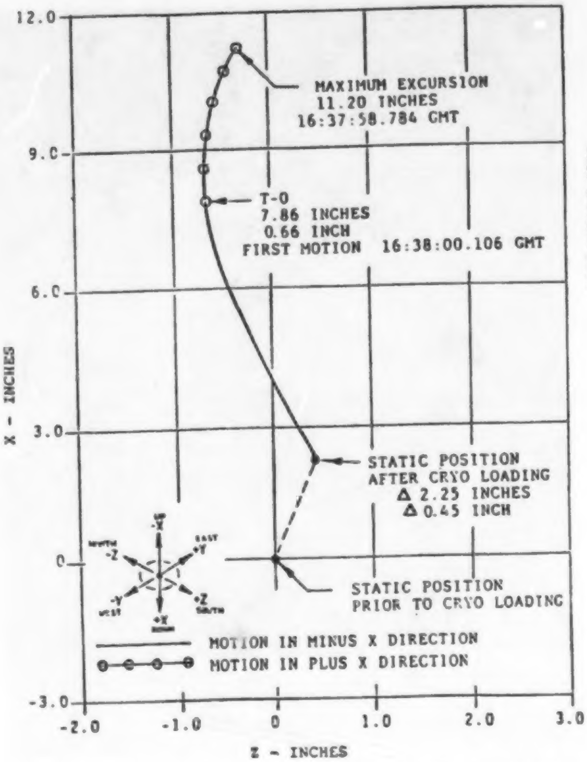
Camera E41 Hydrogen Arm Retract Latchback Failure.

FIGURE 102



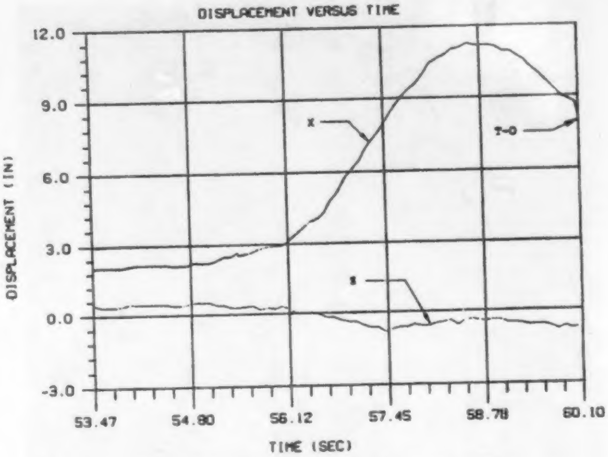
Post-Launch Inspect.

FIGURE 103



Excursion of LO_2 T-0 Carrier Plate, 51-L (From Film Item E-21).

FIGURE 104



LO_2 Carrier Plate Excursions in X and Z Related to Time.

b. *Liquid Oxygen T-0 Umbilical Carrier Plate Excursions*

The motion of the liquid oxygen plate during SSME thrust build-up was measured from film item E21 and plotted in X-Z vehicle coordinates. Figure 103 shows the excursion of the liquid oxygen carrier plate as recorded in film item E21.

This measurement shows the change in carrier plate static position due to cooling and weight redistribution effects of cryogenic loading.

No anomalies were noted in the direction, amplitude, or significant event times associated with the liquid oxygen T-0 umbilical carrier plate excursions from SSME ignition through carrier plate first motion at 16.38:00:106 GMT. The LO_2 carrier plate excursions in the X and Z directions are shown in figure 104.

c. *Ice Debris Observations from Launch Film Review*

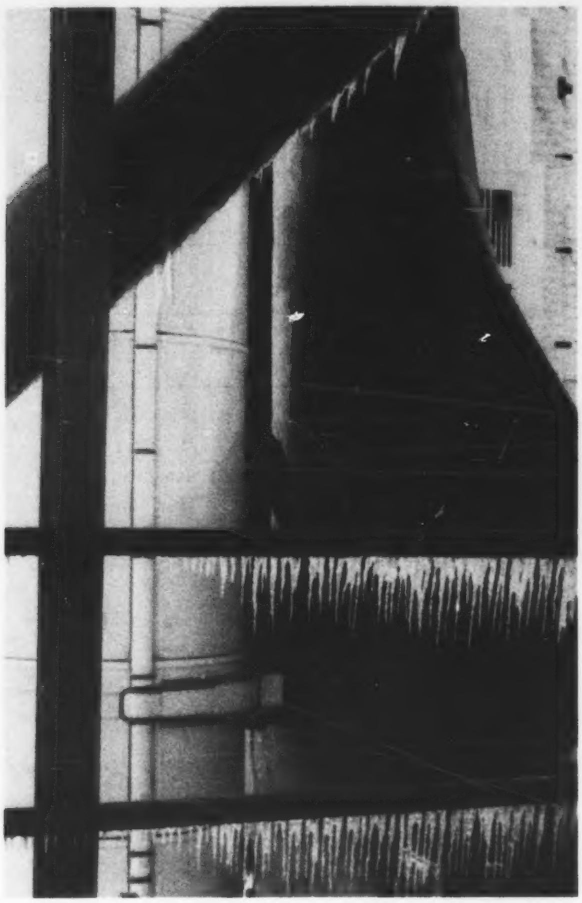
All launch film has been closely reviewed for ice/frost debris, which was evaluated for any possible contribution to the STS 51-L incident. A typical ice condition before launch on the FSS is shown in figure 105.

In general, pad- and MLP-level cameras observed ice falling from facility areas, ice/debris items traversing on the MLP deck level, and particles being blown upward from exhaust holes. The effect of aspiration into the SRB and SSME exhaust holes can also be seen by these cameras. The launch film data review shows no indication of any ice/debris impact damage to the Space Shuttle vehicle that may have contributed to the STS 51-L incident.

Those cameras that were viewing the Orbiter surfaces and the SSME and orbital maneuvering system (OMS) engine nozzle areas showed aft RCS covers and SRB thermal curtain tape being dislodged, as well as FSS/RSS ice falling. Nozzle oscillations, loose tile-gap filler, chips from base tiles, and umbilical ice particles are typical observations. A camera with a southwest vantage point at the MLP deck level showed evidence of black smoke as the right SRB aft skirt clears the frame. Large dark smoke puffs from the right SRB were noted shortly after T-0. None of these cameras document any ice/debris associated with the dark smoke area.

Those cameras viewing the SRB aft skirt, hold-down posts, and blast cover areas showed ice particle translation at the MLP

FIGURE 105



Ice on FSS—Pre-Launch

FIGURE 106

Ice Debris Near Left SRB.

deck level. One camera documented particle aspiration toward the SSME exhaust hole. A piece of water system shim-like material was observed moving upwards and falling to the MLP deck. SRB thermal curtain tape was observed to be loose in several places on the aft skirt. Water was seen coming out of stiffener rings on both SRB's. Ice particles from the over-pressure water trough area were observed having upward translation. Some ice was observed traversing toward the Orbiter wing/tail service mast (TSM) area. Water trough and cardboard-like material was observed coming out of the SRB exhaust hole area. A piece of debris and a smoking/smoldering particle were observed having upward translation at vehicle lift-off.

Cameras viewing the hold-down posts showed fragments and frangible nut pieces coming out of the SRB aft skirt/hold-down post attachment-bolt hole. These particles are seen traveling into the exhaust hole and disappearing into the exhaust smoke. The hold-down post blast covers appear to close normally. When the post-launch inspection determined that the four kick spring/plunger assemblies were missing from the holdpost blast covers, an in-depth film review was performed. Blast cover position for kick spring/plunger assembly escape was determined. Careful analysis of film data did not show any upward moving debris from the hold-down post vicinity when the blast cover position would allow escape of the kick spring/plunger assembly.

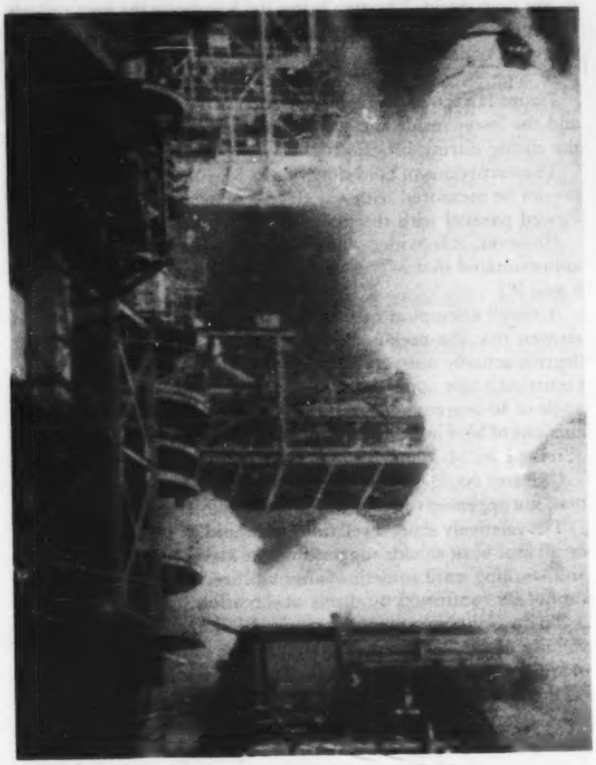
The cameras viewing the facility TSM T-0 umbilicals documented normal operation with little frost.

The cameras located on the fixed service structure show large amounts of ice breaking loose from the FSS and falling soon after SSME ignition (see figure 106). Some ice particles appear to be in excess of one foot in length. The smaller ice particles are observed to travel very close to the Orbiter left wing surfaces and hit the left SRB aft booster/aft skirt surface. A camera documented about 12 objects coming out of the SRB exhaust holes or off the MLP deck during vehicle ascent. Ice/frost is seen coming off the ET-Orbiter umbilicals. Numerous large debris objects are observed in the exhaust plume after the vehicle clears the FSS.

The cameras that view the gaseous hydrogen vent arm documented little frost coming off at retraction. The disconnect and drop appear normal. One camera showed the vent arm failing to latch back firmly at retraction, but showed no subsequent damage because of the failure.

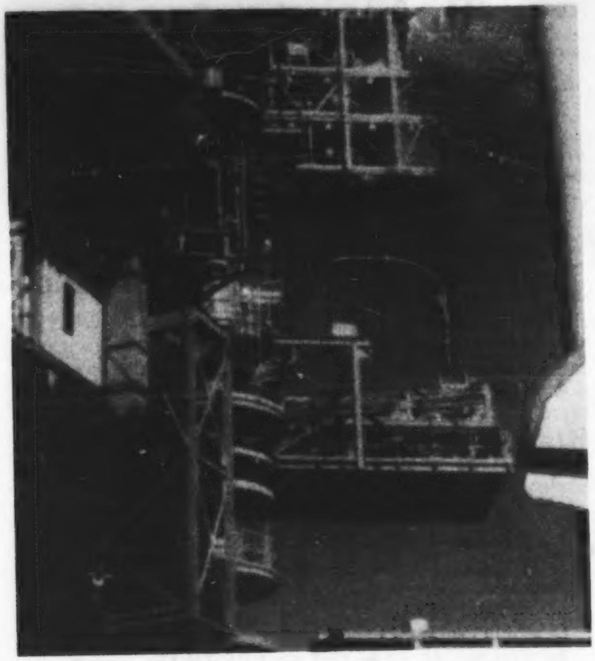
Those cameras viewing from the pad perimeter sites document

FIGURE 107



Ice Debris From FSS.

FIGURE 108



Ice Debris From FSS.

FSS/RSS ice falling (see figures 107 and 108), and those cameras viewing from northern vantage points show smoke from the right SRB at T-0. Typically, no additional debris is seen in these films until the vehicle clears the pad (debris in exhaust plume).

d. *STS 51-L Launch Area Fluid Discharge*

Review of camera E79 film indicated a dark oily-type fluid coming from behind an "I" beam and kick plate adjacent to the ET gaseous hydrogen vent line pivot point at 220-foot elevation. The fluid began discharging prior to SSME startup and continued through T-0.

The probable source of this fluid was water discharging from the 220-foot elevation Firex nozzle and impinging on the inboard kick plate. The film also indicated a small amount of dark fluid discharging from the next lower Firex nozzle.

During a post-launch pad walkdown, two residual material samples were collected from this area and submitted to the Failure Analysis Laboratory. The Laboratory results are shown in the following table:

Dark stain[a-d]	*Light stain*
Sand	SRB Residue
Iron Oxide	Zinc Primer
Kaolin Type Clay	Sand
(Aluminum Silicate)	Aluminum Paint
Aluminum	Titanium Paint
Iron	
Zinc	

Notes:

[a] The water deluge system operated a minimum of 2 hours after launch prior to shutting down.

[b] Samples were collected on 3/6/86.

[c] Analysis was performed on particle size of less than 20 microns.

[d] Limited sample submitted to Laboratory did not allow for weight percent composition.

As indicated by the following Laboratory Report, petroleum compounds were not present in the samples. The samples mainly consisted of sand, rust and paint deposits. Based on this analysis, the dark fluid observed was contaminated water.

As a result, it is recommended that the water deluge system be drained and flushed on a regular basis to remove all water contaminants that are a possible hazard to the Orbiter.

LABORATORY REPORT

MICROCHEMICAL ANALYSIS BRANCH DE-MAO-1, ROOM 1274, 0&C BUILDING NASA/KSC

April 1, 1986

SUBJECT: Wipings on Lint Free Cloth

LABORATORY REQUEST NO.: MCB 180-86

1.0 *FOREWORD:*

1.1 REQUESTER: R. Stevens/NASA/SE-MSD-21/7-0806

1.2 REQUESTER'S SAMPLE DESCRIPTION:

Wipings from FSS near hydrogen vent arm at pad 39-B, Post-launch 51-L.

1.3 REQUESTED:

Determine substances on lint free cloth

2.0 *CHEMICAL ANALYSIS AND RESULTS:*

2.1 Very small particles (less than 20 microns) were removed from the cloth and examined by scanning electron microscopy with the energy dispersive spectroscopy method. Only a very few, tiny particles of typical iron corrosion products, sand, aluminum oxide, zinc primer and miscellaneous organics (containing silicon) were observed.

2.2 The wipes were rinsed and analyzed by infrared spectroscopy for organics. The soiled areas yielded kaolin-type silicate which the non-soiled area did not.

2.3 The amounts of material were so small that weights could not be made (relative to the cloth that the stain was on) therefore, only a qualitative analysis can be reported. If quantitative analysis is desired, clean filter papers should be used, weighed before and after sampling, and as much material should be collected as possible.

e. *Film Analysis of Hold-down Blast Shields*

Post-launch inspection of the hold-down posts revealed that the kickspring assemblies on hold-down posts M-3, 4, 7, and 8 were missing from the blast shield installations (see figures 109, 110, and 111). Therefore, a detailed analysis of engineering film items E27 and E28 was performed to establish a timeline of the operation of the blast shields. Figure 112 shows the relation of cameras E27 and E28 to hold-down posts M-3 and M-7.

The main objective of the analysis was to determine from the performance of the blast shields the exact time period in which the kickspring assemblies were mechanically prevented from leaving the installed location.

The corollary objective was to determine the "worst case" (earliest) time period in which the kickspring assemblies could have become detached.

Figures 113 and 114 provide plots of the angular displacement of the blast shields on hold-down posts M-3 and M-7 as measured on film items E27 and E28, respectively.

The curves are annotated with a line of demarcation at 57 degrees. The area above the line shows the time period in which the kickspring assembly is mechanically "safe," since it is held in by the blast shield. The area below the line shows the time periods in which the kickspring assembly could mechanically come out if it were not additionally locked in by other means, such as the wire rope.

Figure 115 shows the relative location of the kickspring assembly and the lower inside surface of the blast shield that compresses the spring during lift-off.

The excursions of hold-down posts M-4 and M-8 blast shields cannot be measured with any degree of accuracy since they are viewed parallel with the plane of the motion.

However, it is evident that the dwell time and rate of closure approximated that of the shields on M-3 and M-7. (See tables 8 and 9.)

A rough attempt at quantifying the motion of the M-4 shield showed that the prelaunch static position of approximately 52 degrees actually measured 71 degrees. The 74 degrees maximum excursion angle appeared as 80 degrees, while the approximate angle of 40 degrees appeared as 70 degrees. Subjectively, the excursions of M-4 and M-8 appeared consistent with the excursions observed on M-3 and M-7, plus or minus a very few degrees.

Closures could not be determined because of flame obscuration, but appeared to occur within a few milliseconds of each other.

The relatively short dwell time and rapid closure rate observed on all four blast shields suggest that the kicksprings were in place and working until sometime after closure. However, this belief cannot be confirmed by direct observation.

No direct impingement of primary SRB flame is evident in the vicinity of the kicksprings throughout the observational interval of approximately 1.120 seconds. This fact would tend to support the hypothesis that the wire rope restraints were still intact.

Conversely, it is highly probable, based on known drift characteristics of the launch vehicle, that direct primary SRB flame impingement of a magnitude sufficient to burn off the wire rope restraints did occur after 1.120 seconds.

There is no evidence that the kickspring assemblies impacted the vehicle.

Table 8. Angular Displacement of SRB Hold-down M-3 Blast Shield
(from Film E27)

Event	*Excursion, degrees*	*GMT*	*Elapsed time, sec*
Static position	53	16:38:00.018	0.0
First motion detected	53	16:38:00.331	0.313
Start kickspring capture	57	16:38:00.393	0.375
Start dwell at maximum excursion	74	16:38:00.657	0.639
Midpoint of maximum excursion	74	16:38:00.679	0.661
End of dwell	74	16:38:00.720	0.702
End of kickspring capture position	57	16:38:00.853	0.835
Blast shield in closed position	0	16:38:01.138	1.120

Table 9. Angular Displacement of SRB Hold-down M-7 Blast Shield
(from Film E28)

Event	*Excursion,*	*GMT deg*	*Elapsed time, sec*
Static position	52.5	16:38:00.019	0.0
First motion detected	52.5	16:38:00.338	0.319
Start kickspring capture	57	16:38:00.393	0.374
Start dwell at maximum excursion	74	16:38:00.683	0.664
Midpoint of dwell	74	16:38:00.703	0.684
End of dwell at maximum excursion	74	16:38:00.720	0.701
Last measurable closing position	69	16:38:00.827	0.808
End of kickspring capture (extrapolated from plot)	57	16:38:00.897	0.878
Next measurable closing position	33	16:30:01.077	1.058
Blast shield closed position	0	16:38:01.156	1.137

f. *Investigation of MLP-2 Film Data Losses (STS 51-L)*

An unusual number of photo-optical system cameras on the MLP-2 facility failed to generate required data during the launch of STS 51-L. Of the nine positions from which no usable film was obtained, two positions, L-1 (E1), and L-6 (E4) were crucial to the accident investigation, since these viewed from the north quadrant into the right SRB field joint area from which smoke was observed by other cameras during lift-off.

(1) *MLP-2 Camera Configuration for STS 51-L*

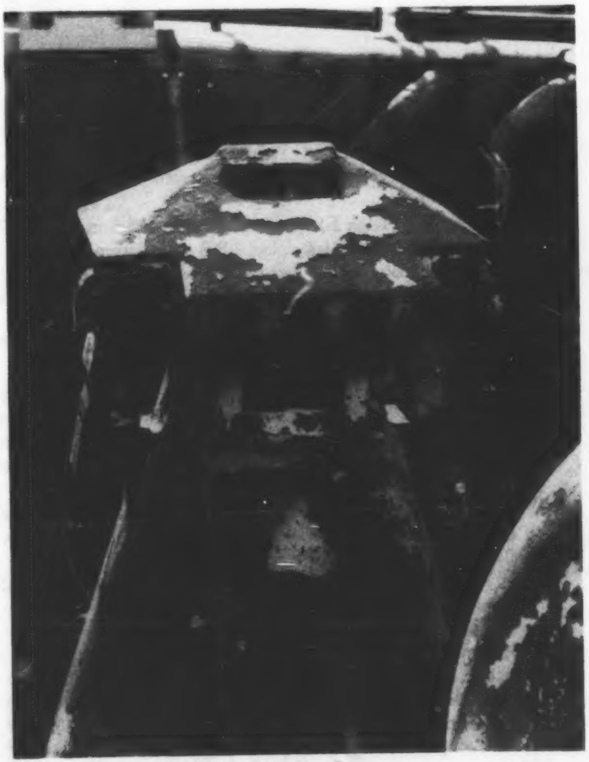
Figure 116 shows the general locations of the photo-optical system cameras on the MLP and the FSS. Figure 117 provides a detailed plan view of the full complement of MLP-2 photo camera positions (28) that were installed for STS 51-L.

The nine cameras that failed to produce data are identified as solid black symbols on figure 117.

Each camera on the MLP is installed in an environmental housing. This housing is purged continuously with dry nitrogen gas, which is fed from the pad 50-psi safety purge system, and each enclosure is held to a positive pressure of approximately 5 psi.

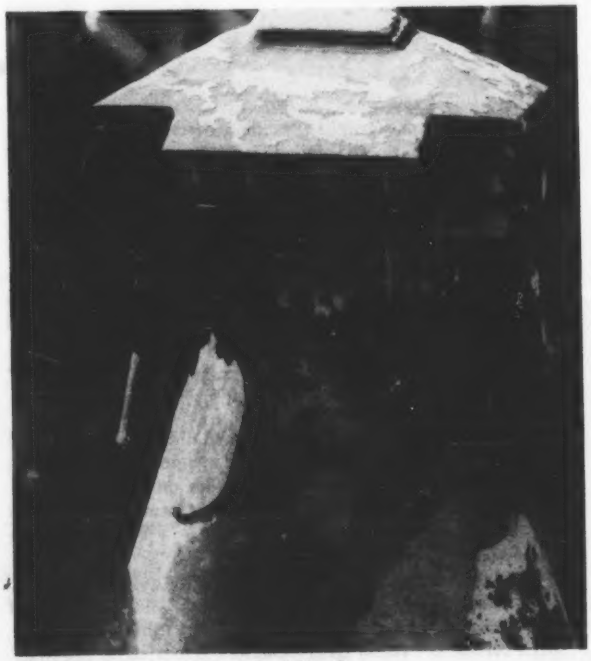
Each camera position, except the TSM positions where it is not needed, is equipped with a high-pressure window purge system fed by the pad 750-psi nitrogen system. In addition, all positions exposed to flame incorporate blast covers, which protect the cables, flex purge lines, and environmental housings from direct flame impingement.

FIGURE 109



Plunger Missing Holddown Post No. 7.

FIGURE 110

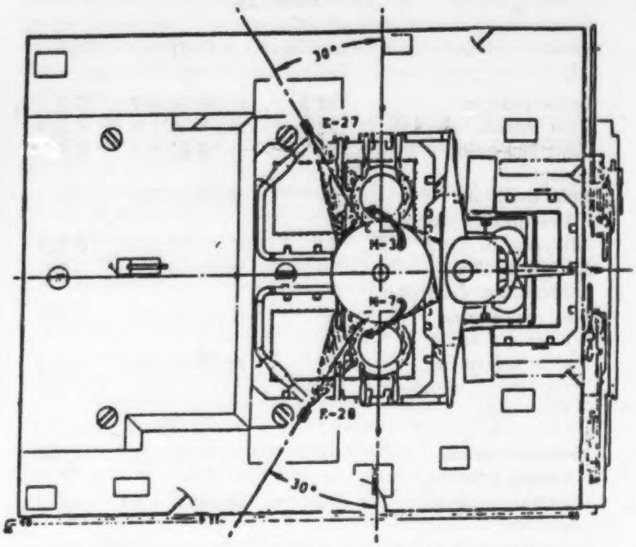


Plunger Missing Holddown Post No. 3.

FIGURE 111

Holddown Plunger Spring.

FIGURE 112



Geometric Relationship on E27 and E28 to Holddown Posts M-3 and M-7.

(2) *Post-launch Condition*

The following paragraphs provide a description of the post-launch condition of the failed items as reported by the photographic operations contractor quality assurance function.

(a) Position L-1 (Item E1) — Camera is located on the northeast corner of the, MLP deck and views the lower ET, SRB's, and Orbiter.

Camera jammed after a very short run (16 feet processed). Jammed film in camera showed that lower film loop was lost and film wound around the upper sprocket and bent the keeper into the film pull-down shuttle mechanism.

(b) Position L-6 (Item E4) — Camera is located on the northwest corner of the MLP deck and views the lower ET, SRB's, and Orbiter.

Jammed film after start. Jammed film was piled up and broken past the first sprocket; film in gate stripped and film piled up on upper sprocket. No film on lower loop.

(c) Position 0-2A (Item E23) — Camera is located on the south side of the MLP deck and views the +Y OMS engine nozzle.

Jammed film after start. Film shredded at lower sprocket; numerous windings on upper sprocket and two layers of film in and out of first sprocket. No film remaining in gate.

(d) Position B-7 (Item E11) — Camera is located on the MLP deck and views the left SRB northeast hold-down post (HDP) 7.

Short camera run — 30 feet processed. Camera condition normal — i.e., no break in film or no jam noted. Apparent camera stoppage as if electric power cutoff.

(e) Position B-8 (Item E12) — Camera is located on the MLP deck and views the left-hand SRB HDP 5.

Film jam after short run (20 ft processed). Jammed film piled up on upper loop. Lower loop was lost.

(f) Position B-9 (Item E13) — Camera is located on the MLP deck and views the left-hand SRB southwest HDP 6.

Jammed film on start. Remaining film in gate contained stripped perforations. Film was piled up at lower and upper keepers.

(g) Position B-6 (Item E16) — Camera is located on the MLP deck and views the left-hand SRB skirt, sound suppression water troughs, and left-hand lower Orbiter body flap.

Film break during start. No jam. Clean break at first sprocket. No film in gate.

(h) Position B-10 (Item E14) — Camera is located on the MLP deck and views the left-hand SRB northwest HDP 8.

Jammed film at start. Film jam after appropriately 2 feet — film jam on upper keeper, wound on top sprocket and pile-up between timing block and film gate. Section of film gate had torn perforations. Film broken prior to take-up flange.

(i) Position L-2 (Item E5) — Camera is located on the east side of the MLP deck and views the Orbiter right wing, body flap, and lower ET/SRB.

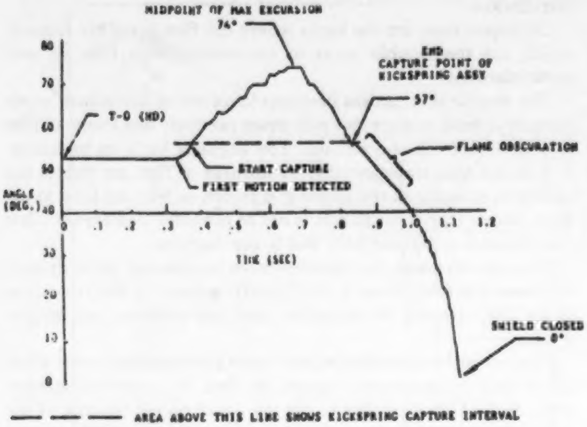
Jammed film on start. Remaining film in gate contained punched perforations, pile-up at lower sprocket.

(3) Brief Description of Cameras

All of the cameras used on the MLP close-in positions are Milliken models DBM-4, DBM-5, or in two locations Redlake model Lo-Cam. All locations except positions T-1 (E21), T-2 (E22),and L-2 (E5) which are 200 frames per second are operated at 400 frames per second.

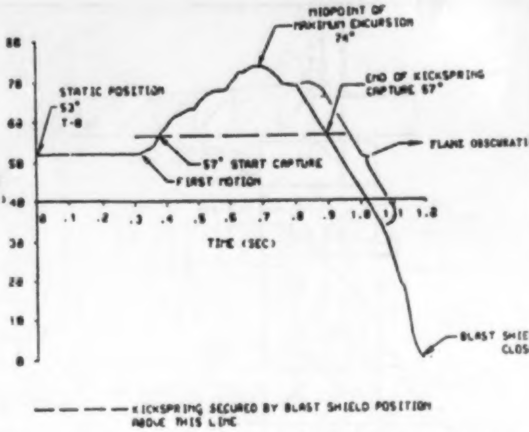
The cameras are loaded with 200 feet of Eastman VND color film, and have an approximate running time of 20 seconds. The cameras were programmed to start at T-10, T-11, or T-12 seconds depending on the position. This start time allows the cameras

FIGURE 113



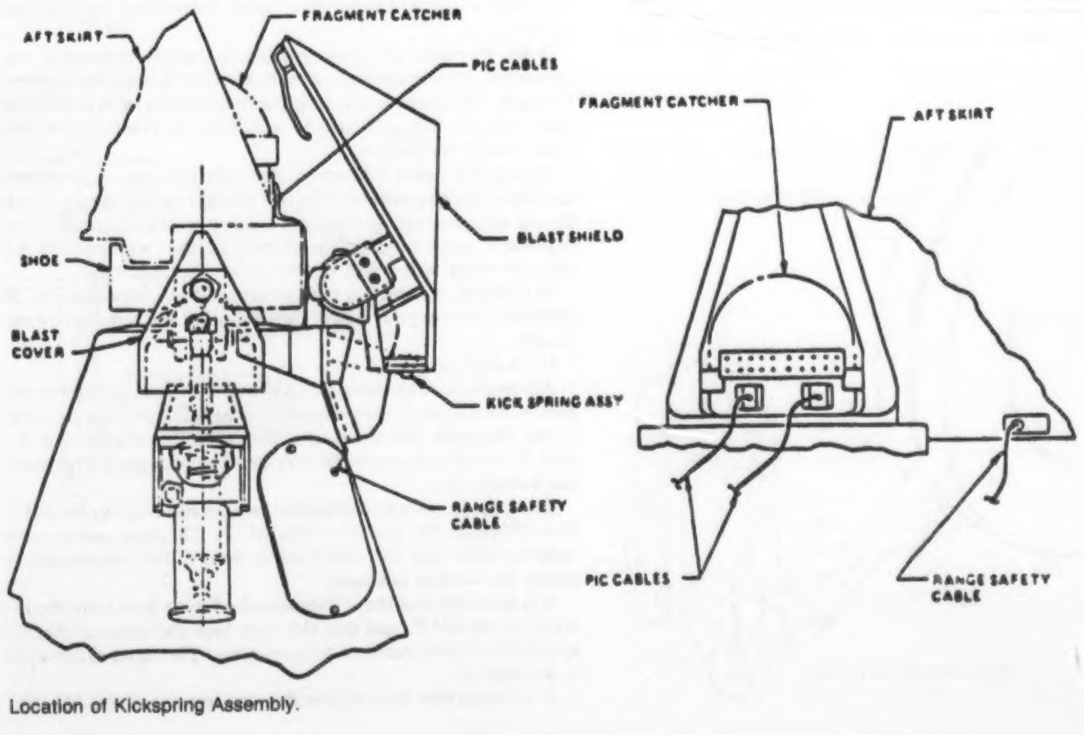
Angular Displacement of Blast Shield on Holddown Post M-3 (Film E27) (STS 51-L).

FIGURE 114



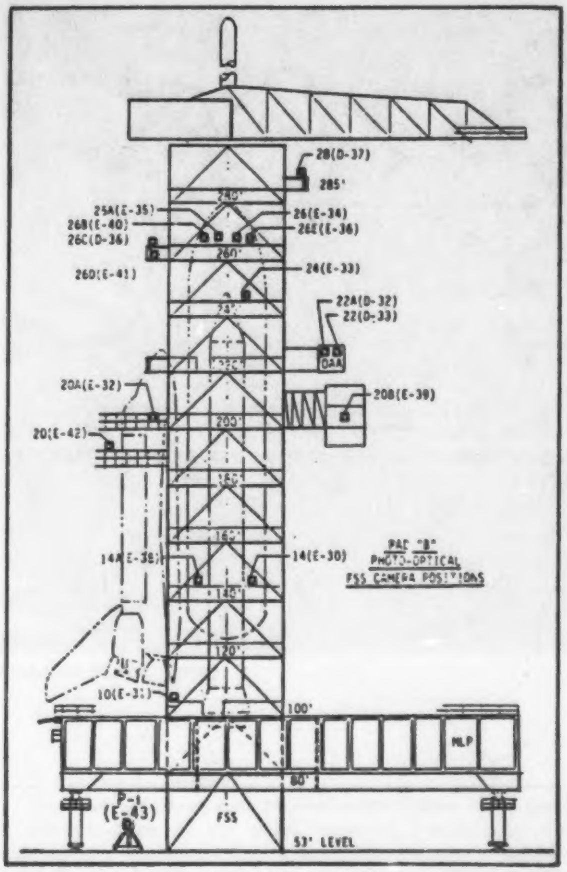
Angular Displacement of Blast Shield on Holddown Post M-7 (Film E28).

FIGURE 115


AFT SKIRT
FRAGMENT CATCHER
PIC CABLES
BLAST SHIELD
SHOE
BLAST
COVER
KICK SPRING ASSY
RANGE SAFETY
CABLE
FRAGMENT CATCHER
AFT SKIRT
PIC CABLES
RANGE SAFETY
CABLE

Location of Kickspring Assembly.

FIGURE 116



Location of Cameras on LC-39B Fixed Service Structure (51-L Configuration).

to reach nominal running speed by SSME ignition.

Figure 118 shows the details of the type of camera movement involved in the Milliken cameras that dominate the MLP-2 installation.

Of importance are the loops where the film is tightly wound, which are the trouble spots in connection with film set and embrittlement.

The shuttle mechanism becomes involved in the failure mode because it must engage and pull down precisely one frame of film at a time, 400 times a second. The slightest back-up or hesitation in the film transport due to stiffness or film set causes the shuttle to miss the perforations and punch or tear the film, starting a jam or tear. This failure is not as probable in a camera that incorporates a register pin, but it can happen.

Film set can cause the sprocket teeth to miss one or more perforations if the set forms a bend (curl) opposite to the curvature of the path around the sprocket, and this problem can initiate a jam.

Film set and embrittlement can cause film breakage even when the shuttle or sprockets engage the film in a normal fashion because the film is unable to absorb the dynamic loading of the acceleration during start-up and is unable to bend quickly around the sprockets without snapping apart.

(4) *Analysis of Factors of Highest Probability*

This section of the report deals with the identification and assessment of the known factors of highest probability that could have contributed to the film losses.

Three primary factors that are known to cause film set (film embrittlement and distortion) resulting in film breakage and jams, particularly in high speed cameras, were present to some degree during the launch preparations of STS 51-L.

These are (1) film threaded and sitting in the camera for an extended period to time, (2) film drying out due to low humidity, and (3) low temperature. Combined, the effect of these factors is additive and cumulative with time.

(5) *Findings*

Because of launch delays and recycling of the STS 51-L launch, the cameras sat on the pad with film loaded for approximately 72 hours, which was about three times longer than on a normal operation.

After 48 hours, the photographic operations contractor was allowed to re-enter the pad and turn the film through the cameras by hand. The purpose was to advance fresh film from the supply spool into the film gate area to minimize the possibility of film jams caused by film set.

During the entire 72-hour period, the film was subjected to the dehumidifying effects of the dry nitrogen safety purge, which flowed continuously through the environmental housings. This exposure undoubtedly maximized the embrittlement characteristics of the film for the given period of time.

In addition, the ambient temperature in the vicinity of the MLP was below freezing during the early morning hours preceding the launch.

(6) *Assessment of the Factors*

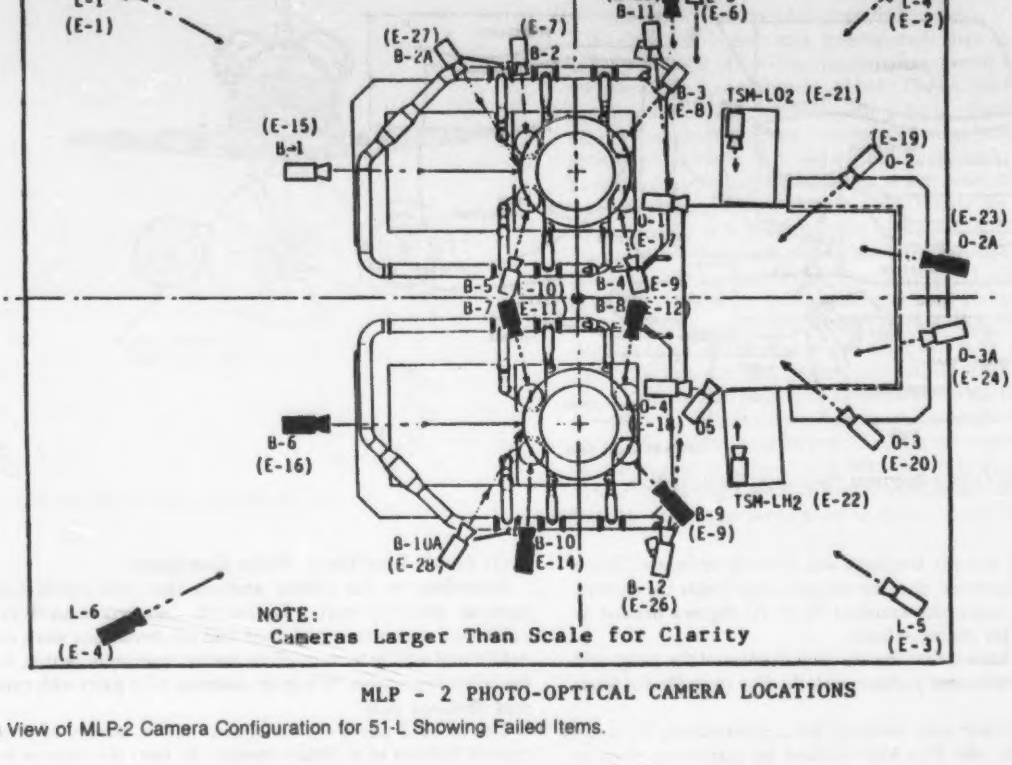
Although there has been much speculation concerning the impact of the low temperature conditions as being the leading cause of the film jams and breakages, the evidence suggests that the cold in combination with the dry gaseous nitrogen purge were the contributors.

First, the purge gas entering the camera housings on the MLP flows through the interior of the MLP. The lines are ¼-inch stainless steel, and run along the ceilings of the compartments under the camera positions.

It is probable that these lines absorbed some heat from the interior of the MLP, and that this heat kept the cameras slightly above the outside ambient temperatures. The exact differential is not known.

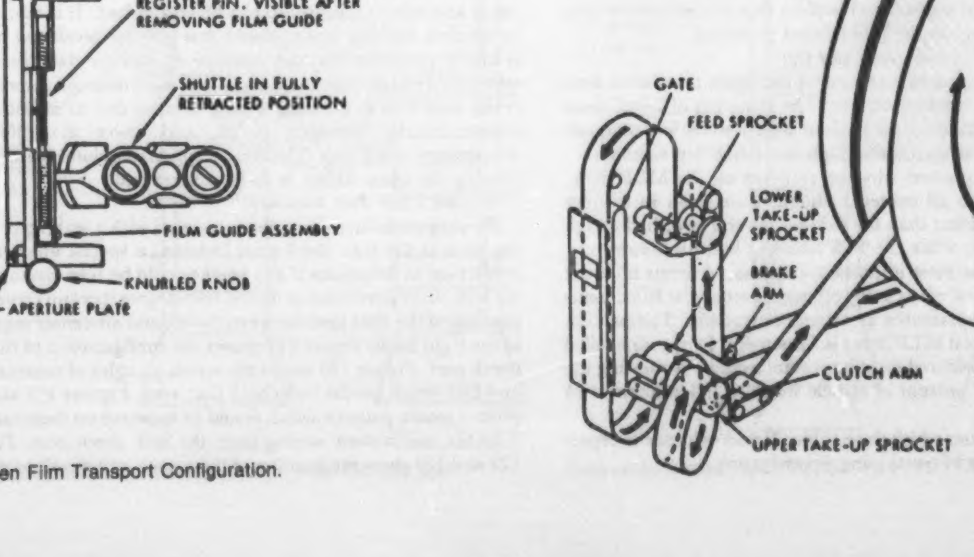
It is considered improbable that the interior of the MLP or

FIGURE 117


- Z +
L-1
(E-1)
L-2
(E-5)
(E-25)
B-11
L-3
(E-6)
L-4
(E-2)
(E-27)
B-2A
(E-7)
B-2
B-3
(E-8)
TSM-LO2 (E-21)
(E-15)
B-1
(E-19)
O-2
O-1
(E-17)
(E-23)
O-2A
+
Y
-
B-5
(E-10)
B-7
(E-11)
B-4
E-9
B-8
E-12
O-3A
(E-24)
O-4
(E-18)
O5
B-6
(E-16)
O-3
(E-20)
TSM-LH2 (E-22)
B-9
(E-9)
B-10A
(E-28)
B-10
(E-14)
B-12
(E-26)
L-6
(E-4)
NOTE:
Cameras Larger Than Scale for Clarity
L-5
(E-3)
MLP - 2 PHOTO-OPTICAL CAMERA LOCATIONS

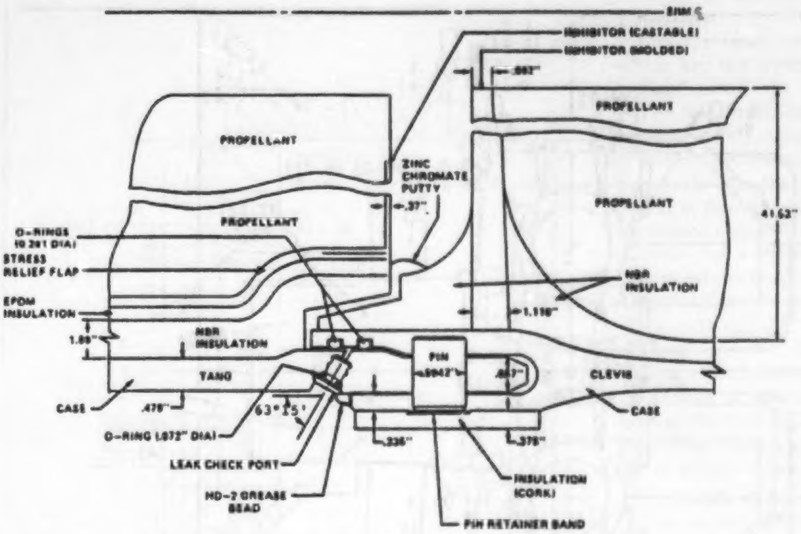
Plan View of MLP-2 Camera Configuration for 51-L Showing Failed Items.

FIGURE 118


FILM GATE
TENSION RAIL
REGISTER PIN, VISIBLE AFTER REMOVING FILM GUIDE
SHUTTLE IN FULLY RETRACTED POSITION
FILM GUIDE ASSEMBLY
KNURLED KNOB
APERTURE PLATE
SUPPLY SPOOL
TAKE-UP SPOOL
GATE
FEED SPROCKET
LOWER TAKE-UP SPROCKET
BRAKE ARM
CLUTCH ARM
UPPER TAKE-UP SPROCKET

Milliken Film Transport Configuration.

FIGURE 119



AFT Segment/Aft Center Segment Field Joint Configuration.

the gas flowing into the housings was freezing or below. There is little doubt, however, that the temperatures inside the camera housings were below the nominal 60 to 70 degrees needed to minimize film set characteristics.

Second, it is known that the absolute dryness of the purge gas creates an embrittlement problem with the film regardless of other factors.

It is probable that after "soaking" for approximately 72 hours in dry nitrogen, the film had reached its maximum dryness especially in the outer layers of the film supply spool and in the mechanism.

Finally, it is highly probable that in spite of the precautions taken by the photo operations contractor, the film that was advanced was already on the way to becoming brittle, and quickly "set-up" in the transport mechanism.

The one exception to the film jam/break failure mode is position B-7 (item E11). The failure mode of this position appears to be a typical case of an open circuit due to launch environmental wear-and-tear effects on service cables, etc. An analysis of this item has not been completed to the point that it conclusively does not have a bearing on the other failed positions.

(7) *Factors or Anomalies Not Ruled Out*

The pattern of camera locations of the items that failed does not appear to be a random pattern. The grouping of failed items cannot be rationalized on the basis of purely statistical rationale without reaching an extremely high improbability estimate.

It cannot be explained why the cameras on the MLP deck, which according to all evidence should have been in a more favorable environment than the cameras on the FSS, had a high failure percentage, while the FSS cameras had no failures.

The fact that the most important cameras, in terms of direct viewing of the critical event at lift-off, were among the failed items is only partially explainable as a random statistic. The percent of failed items to total MLP items is 32 percent. Of the nine failed items, four are considered most important as directly viewing the smoke event. The percent of critical items to failed items is 44 percent.

Other factors about which there is insufficient evidence to report will be the subject of continuing investigation.

(8) *Factors Ruled Out as Failure Contributors*

According to the system analysis that was conducted, all cameras received starts. Pre-launch and post-launch system validation tests were conducted and no deviations were noted. Additional evidence to confirm system operation is that two of the failed items were "Y"d from common wire pairs with cameras that obtained data.

The MLP-2 photo-optical system has no history of previous camera failures of a similar nature. In fact, the reverse is true in that the reliability of the MLP-2 photo-optical system has been extremely high.

The photographic operations contractor personnel are well qualified, have extensive experience with the system, and have adequate inspection and checkout procedures with supporting documentation.

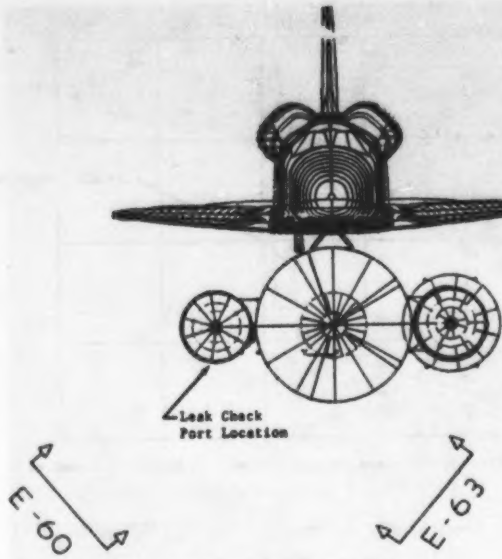
(9) *Interim Conclusion*

In view of the physical evidence of film jams and breaks in the camera and confirmation of the adverse environmental conditions surrounding the cameras at launch time, it is concluded that a cause and effect relationship can be established. It is tentatively concluded, barring new evidence that may be developed, that it is highly probable (but not conclusive) that the data losses are attributable to the combination of extended time the cameras sat ready with film at the launch pad, dryness due to extended exposure to dry nitrogen purge, and lower than nominal temperature conditions. The one exception mentioned earlier concerning the open circuit is to be determined.

4. *Leak Check Port Assessment*

To support failure scenarios associated with a leaking or missing plug at the leak check port location, a special analysis was performed to determine if any smoke could be seen issuing from the leak check port location on the zero-degree (bottom centerline) position of the field joint between the aft and aft-center segments of the right SRB. Figure 119 shows the configuration of the leak check port. Figure 120 shows the viewing angles of cameras E60 and E63 which see the leak check port area. Figures 121 and 122 present smoke patterns which would be expected on these cameras if smoke was indeed issuing from the leak check port. Figures 123 and 124 show the location of the smoke as it develops during

FIGURE 120



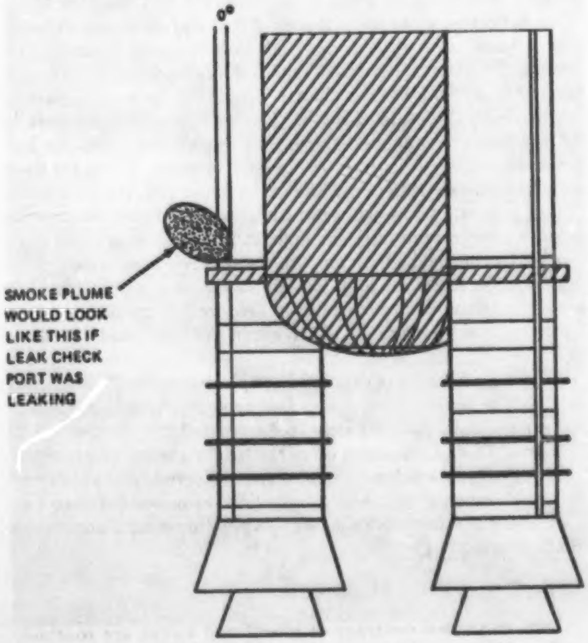
Viewing Angles From Cameras E60 and E63.

the initial phase of the smoke buildup. These two figures were made on a film motion analyzer which graphically depicts the film events. As can be seen from the figures, the observed smoke patterns are totally inconsistent with smoke from the leak check port area. Thus, the determination was made that no smoke issued from the leak check port.

5. *Structural Breakup Characterization*

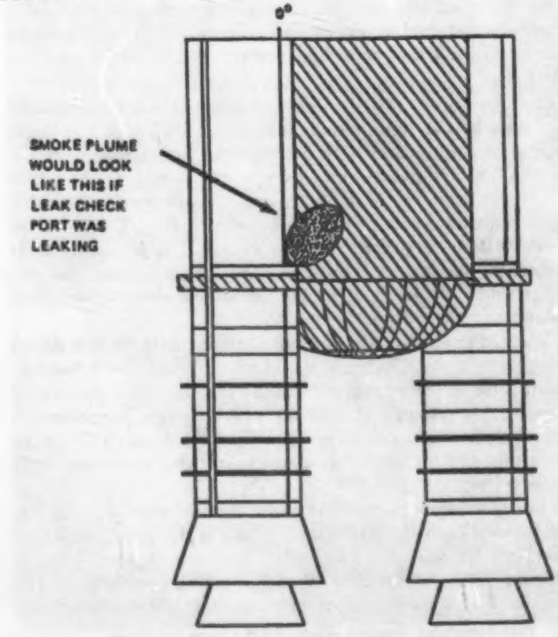
Analysis of visual and telemetered data has enabled a characterization of the structural breakup events associated with the loss of the Space Shuttle vehicle. The events began with the compromise of the right SRB case joint at lift-off. At about 60 seconds into the flight, this compromise was manifested by a burn through of the SRB which bathed the external tank with propellant burn products near the SRB lower attach fitting area. The burn through plume penetrated the external tank at approximately 65 seconds MET and caused liquid hydrogen to spill out. At approximately 72 seconds MET, the burn through plume caused loss of the lower attach fitting load path which allowed the SRB to begin a counterclockwise rotation around the upper strut area. The structural weakening of the external tank aft region led to the failure of the aft end of the hydrogen tank which dumped hydrogen into the base region and caused the loss of integrity of the Orbiter load path. This failure allowed the Orbiter to begin moving in relation to the external tank. A combination of (1) the effects of a sudden large forward thrust of the external tank caused by the expulsion of hydrogen from the aft end, (2) the possible contact of the right SRB at the forward attach area, and (3) the possible contact of the Orbiter in the intertank region caused a

FIGURE 121



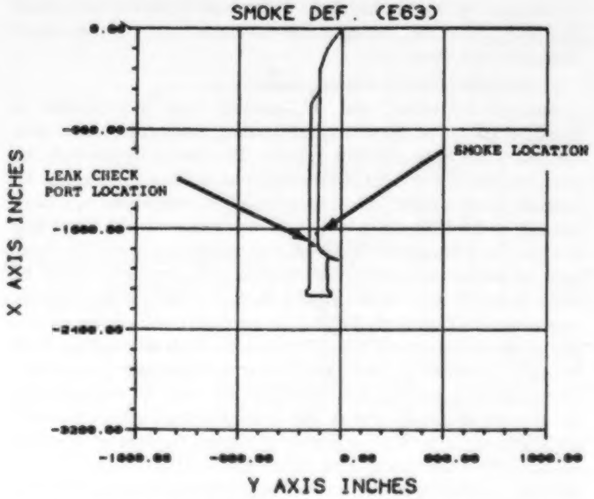
Postulated Smoke Plume Appearance From Camera E63.

FIGURE 122



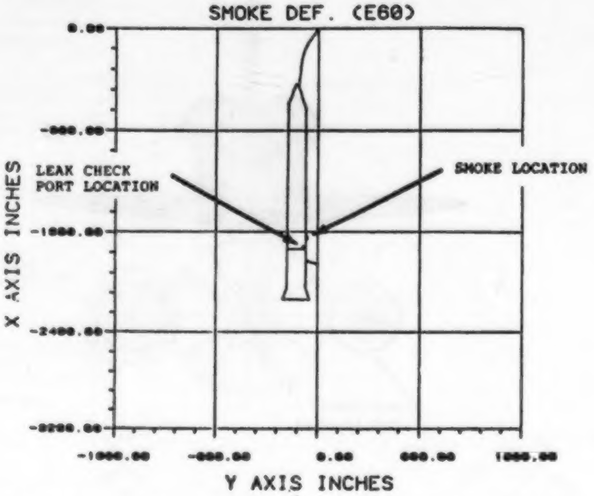
Postulated Smoke Plume Appearance From Camera E60.

FIGURE 123



Smoke Locations Using Camera E63 Data (a) 0.854 Second MET.

FIGURE 124



Smoke Locations Using Camera E60 Data (a) 0.731 Second MET

massive structural failure of the intertank area including the liquid oxygen tank aft dome and liquid hydrogen forward dome. The violent decompression and vaporization of the liquids in conjunction with the aerodynamic loads and some fringe burning caused complete structural loss of the external tank and sent large amounts of external tank debris from the vapor cloud. The SRB's were seen exiting the vapor cloud and continuing to fly until range safety destruct.

The actual breakup of the Orbiter was almost entirely obscured from view by the vapor cloud. It is expected that aerodynamic loading in conjunction with SRB plume impingement as the boosters thrusted past the Orbiter were the main contributors to the Orbiter breakup. Many fragments are noted exiting the ET cloud; however, very few are readily identifiable. These few include the left wing and the crew cabin. The nonidentifiable fragments are noted tumbling and spinning against the background of the ET propellant cloud/SRB plume and occasional flashing of reflected light.

Depicted in figure 125 is an initial stage of the vehicle debris emerging from the ET cloud/SRB plume. The distinctive reddish-brown color of the nitrogen tetroxide oxidizer from the orbital maneuvering system and reaction control system propellants is observable in this figure. Visible in figures 126 and 127 are the crew cabin and the left wing intermingled with numerous small debris segments.

The black bands on the wing at the forward edge of the elevon panels (see figure 127) indicate that this is the upper surface—hence, the left wing.

Figure 128 shows the crew cabin descending nose forward with debris and an outgassing aft of the cabin at 89.452 seconds MET.

6. *Post Structural Breakup Right SRB Characterization*

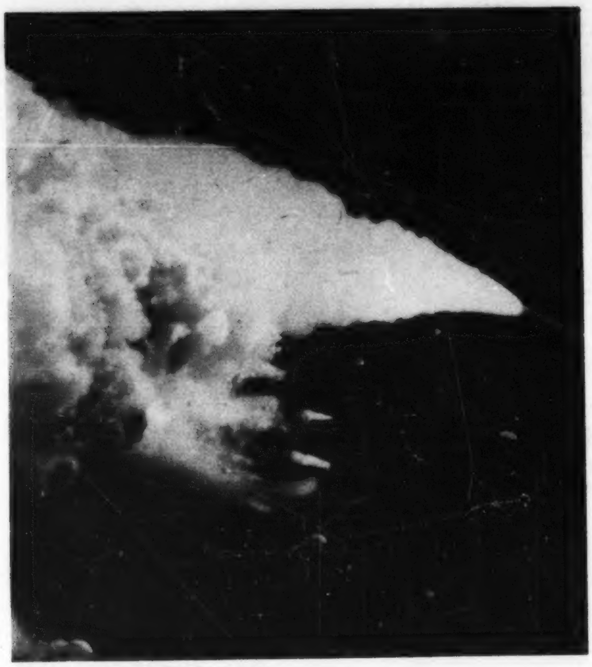
A special analysis was undertaken to characterize the condition of the right SRB up to the point of range safety destruct in an attempt to determine the maximum size of the source of the flare (anomalous plume). Figure 129 shows the SRB immediately after it exists the vehicle breakup cloud. External tank hardward is visible still attached to the SRB and deflecting the flare. This deflection gives the impression that the entire aft segment has a burn through. As the SRB continues to fly away, its counterclockwise rotation and varying angle-of-attack cause the appearance of the flare to change drastically. When the flare is on the windward side of the SRB as in figure 130, the flare is blown back and wrapped around the vehicle and gives the impression of a large circumferential burn through. When the flare is on the leeward side of the SRB as in figure 131, the flare gases fill the separated flow area on the back side and give the impression of a large axial burn through. All of these impressions are caused by flowfield effects and are not true representations of the flare source. Recovery of the aft-center segment of the right SRB confirms the burn through location described in previous sections of this report (see figure 132). Figures 133, 134, and 135 show the recovered hardware.

The right SRB exits the cloud at approximately 75.8 seconds MET. The separated nose cap and deployed drogue parachute are observed at approximately 76.4 seconds MET. At around 80 seconds MET, a reflection off of the SRB recovery system remnants (drogue parachute and risers) is observed (and confirmed by enhancements) on the side of the SRB as shown in figure 136. This event was initially reported as a possible second anomalous SRB plume.

7. Review of Prior Flight Film

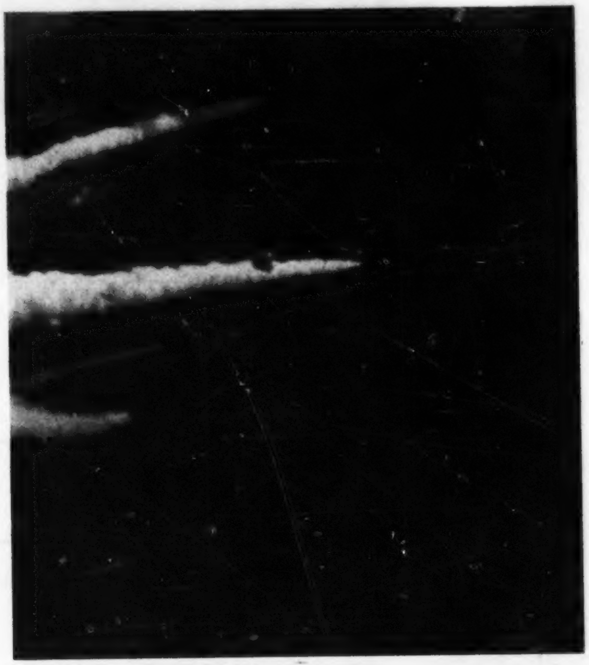
Film and video coverage of lift-off and ascent are routinely reviewed as part of the postflight mission evaluation. Typically,

FIGURE 125



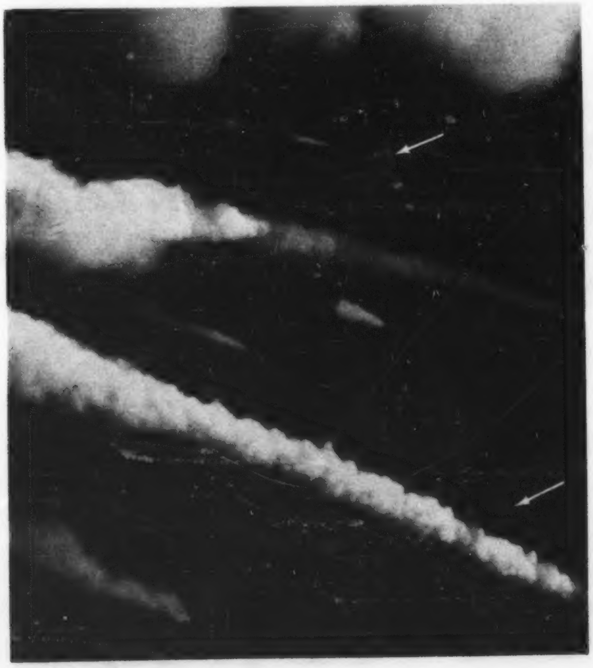
Camera E202 at 76.464 MET

FIGURE 126



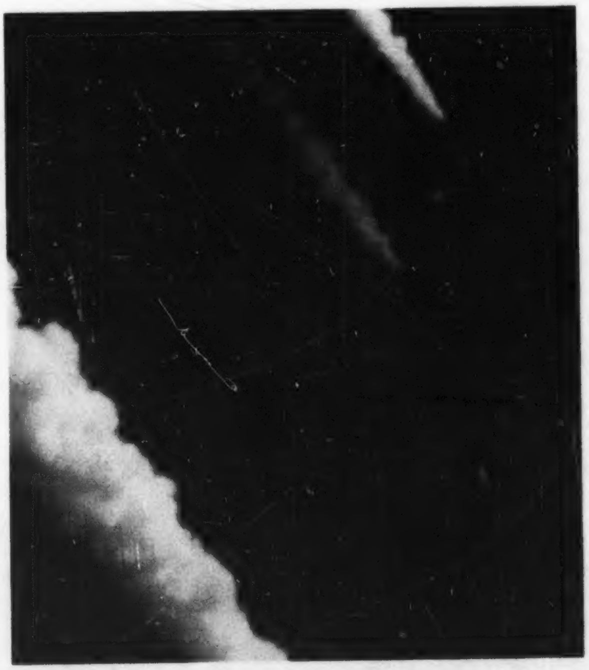
Crew Cabin, Wing and Debris

FIGURE 127



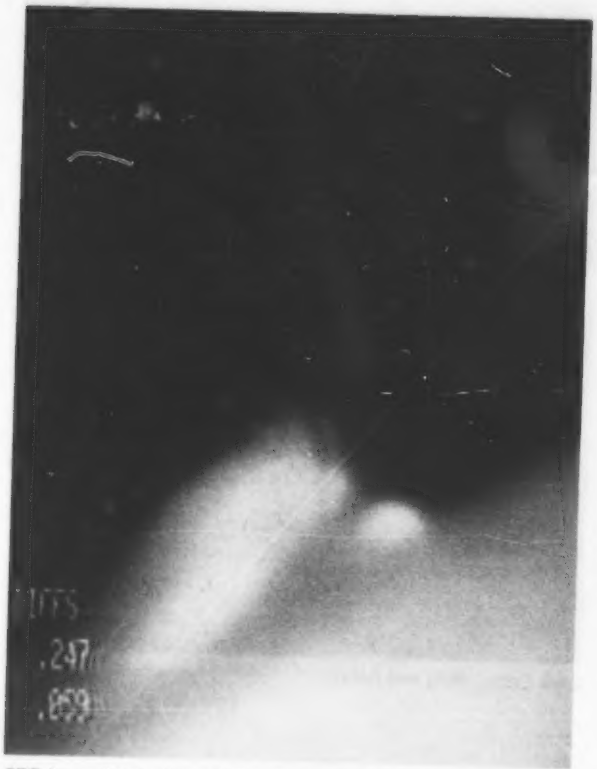
Camera E202 at 78.531 MET

FIGURE 128



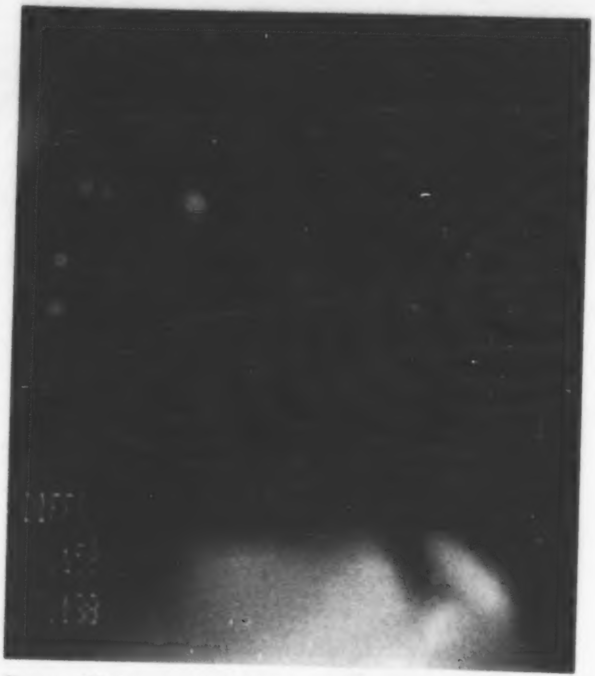
Orbiter Crew Cabin, Nose Forward at 89.452 MET

FIGURE 129



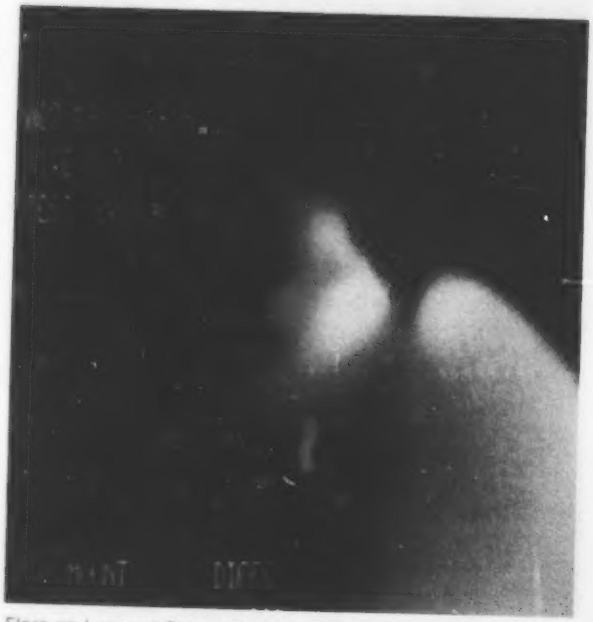
SRB Immediately After Exiting Breakup Cloud.

FIGURE 130



Flare on Windward Side of SRB.

FIGURE 131



Flare on Leeward Side of SRB.

FIGURE 132

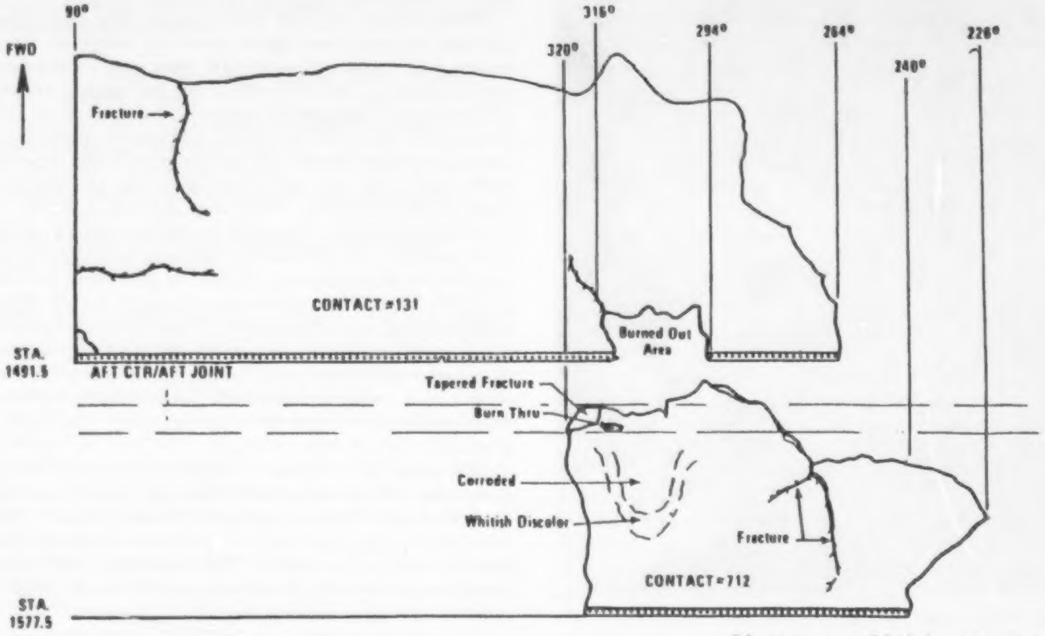
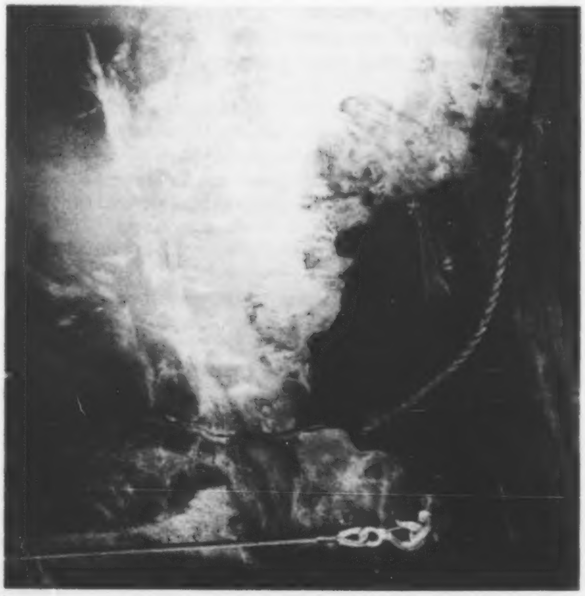

90°
316°
294°
264°
228°
320°
240°
FWD
Fracture
CONTACT #131
Burned Out Area
STA. 1491.5
AFT CTR/AFT JOINT
Tapered Fracture
Burn Thru
Corroded
Whitish Discolor
Fracture
CONTACT #712
STA. 1577.5

Diagram provided by SRR Team

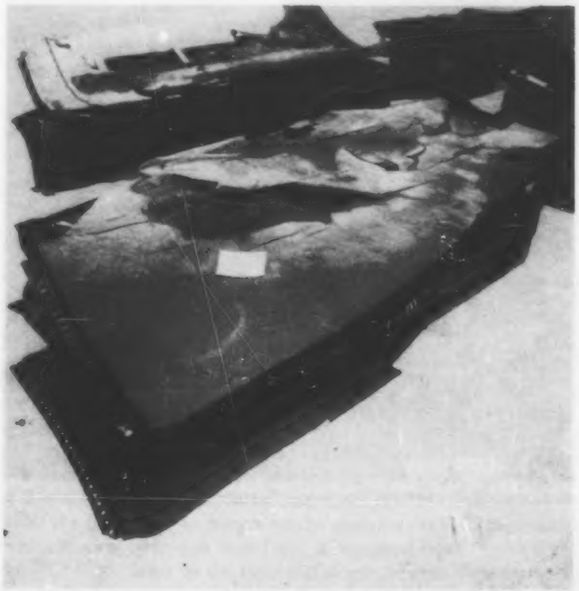
SRB Recovered Debris—RH Aft Segment (View From Outboard).

FIGURE 133



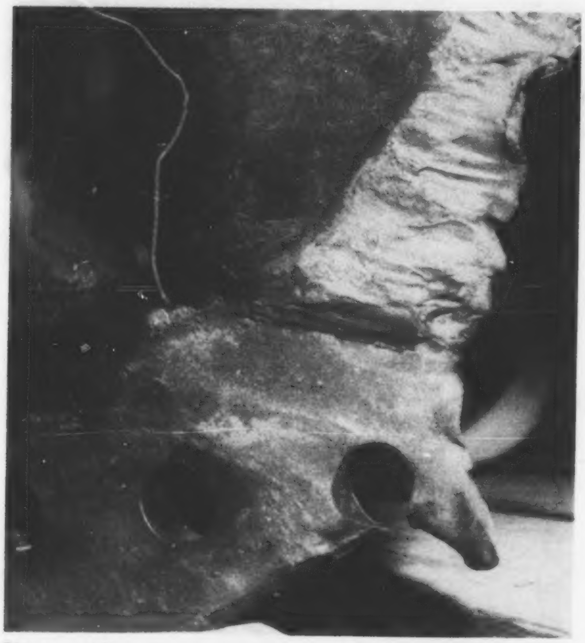
Recovered SRB Aft Center Segment.

FIGURE 134



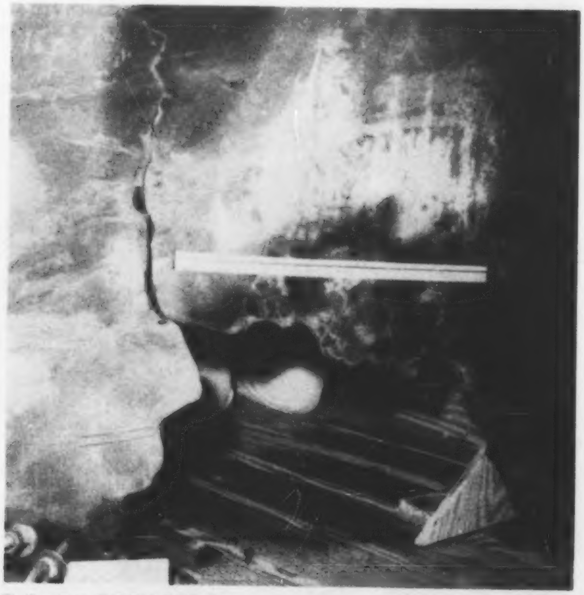
Recovered SRB Aft Center Segment.

FIGURE 135



Closeup of Burn Through on Recovered Aft Center Segment.

FIGURE 136



Reflection Off RH SRB Recovery System.

teams of 6 to 15 engineers and photo analysts study each film to search for possible anomalous events. Screening notes are routinely written for each film to document any findings. A review of these screening notes did not reveal any evidence of anomalous smoke or plume leakage on prior flight film.

Subsequent to the STS 51-L mission, film and video from previous missions were again viewed to search for any subtle evidence of smoke or vapors that were possibly overlooked in earlier viewings. Included within this rescreening were the lift-off coverages of the specific missions (STS-2, 41-B, 41-C, 41-D, 51-C, 51-A, and 61-C) in which postmission teardown inspection had revealed evidence of heat-induced O-ring damage in the SRB field joints. As the earlier screening had indicated, no evidence of anomalous smoke or plume was detected.

Several instances of apparent anomalous smoke or flame need to be clarified to avoid possible confusion in the future. On mission STS 51-B, a small wisp of white or gray vapor was observed in NASA Select Video above the + Z side of the left SRB aft attachment ring. A careful review of that event revealed that the vapor appeared about 8 milliseconds before SRB ignition and that it was most likely water mist abruptly blown around by the Space Shuttle main engine plume effects. Similar wispy vapors are also occasionally noted on the SRB stiffener rings where water tends to collect.

Also noted on a number of flights (41-D, 51-A, 51-C, 51-J, 61-B, and 61-C) are significant flames on the ET aft dome after T + 90 seconds. This appearance of flames is caused by the recirculation of plume gases and ET insulation outgassing products into the vehicle base region. This outgassing and recirculation which occurs on all flights, is accounted for in the design of the vehicle, and is completely normal.

8. Other Government and Industry Analyses and Enhancements

a. Initial Analyses

Several image analysis facilities, in addition to those at JSC and MSFC, were involved in the analysis of STS 51-L imagery. These remote facilities were:

National Photographic Interpretation Center (NPIC)
U.S. Air Force (USAF)
Wright Patterson AFB, Dayton, Ohio (WPAFB)
Space Division, Los Angeles, CA
Jet Propulsion Laboratory (JPL)
Lockheed Missiles and Space Corporation (LMSC)
ITEK, Inc.
Exxon Production Research Company (EPRCO)
Other government facilities.

These facilities were originally given the following tasks:

(1) Possible Smoke Puff—Analyze E207, frame 23 for possible existence of vapor that could be considered a precursor to the subsequent flare on starboard SRB (frame 42).

(2) Study of Early Development of Flare on Starboard SRB—Using E207 frames 35, 36, 42, 55, and 96, and E206 frame 131, characterize early development of flare, including time of initial flare, point of origin, orientation of flare, dimensions, and rate of growth. Assess direct visibility versus reflections from Shuttle components.

(3) Enhancement of Spatial Content of Scene—Using E206, frame 634, enhance resolution of entire Shuttle image and stretch contrast or perform other enhancement to improve ability to assess make-up and orientation of apparent vapor concentration around Shuttle, especially around belly of external tank. Also need to assess any apparent relative motion of Orbiter components.

(4) Enhancement of Apparent Vapor Patterns—Enhance E206, frames 634, 635, and 636 to show maximum information on apparent vapor patterns rapidly developing in vicinity of Shuttle.

(5) Physical Location of Bright Spot—Using E206, frames 635 and 636, determine location of bright reddish-orange spot. Is there any apparent change in position relative to the Shuttle between the two frames?

(6) Location of Origin of Bright Spot—Using E206, frame 639, locate origin of developing bright sport near forward tip of the external tank.

(7) Multi-Image Correlation of Flare Development—Using E206, frames 131 and 145 in conjunction with E207, frames 109 and 110, analyze conditions developing on starboard SRB that would explain initial visibility from the south (E206).

(8) Composition of Plume—Using data available from E60 and E63, assess the feasibility of determining spectral characteristics of the smoke plume, and if feasible, perform such analysis.

(9) Geometric Characteristic of Smoke—Using frames from E60 and E63, determine the best estimate of the point of origin of the smoke plume. Also include size, shape, location, and rate of growth. Note any other characteristics associated with plume.

The analyses were hampered in this initial stage (2 weeks after the accident) by the lack of suitable photographic materials to support digital analysis. All organizations reported problems in digitizing from the cut-film transparencies and most resorted to digitizing from 8 × 10 positive prints or abandoned the effort entirely. Exxon and one other laboratory had contact transparencies of E60 and E63 and performed analyses of the smoke at launch.

During this time period, Exxon concentrated on determining the time of origin of the burn through and in generating enhanced views of the sequence of events from 70 and 73 seconds MET, as viewed on E207. Exxon then concentrated on enhancements of photography pertaining to the puffs of smoke at launch.

JPL received contact positive transparencies of the 70mm film and performed a detailed analysis of the time of origin and development of the flare at initial burnthrough.

b. *Follow-On Analyses*

A follow-on effort consisted of performing task assignments, using better film and ancillary products, during the last week in February. The task assignments, based on updated interpretation of the focus of the investigation, as well as on assessment of each facility's strong points, as evidenced in their initial response, were as follows:

(1) *National Photographic Interpretation Center*

(a) Origin and Development of Flare—Using additional material (E203, E217, and E207 transparencies), determine time and location of the initial flare from burn through. Locate point on the SRB in both longitude and circumference. Characterize growth of flare projected into by X/Z and Y/Z planes, and characterize apparent progression of origin around the circumference of the SRB. Include roll/frame numbers as well as time of specific events.

(b) Characterization of Normal Reflection from Shuttle—Using Intergraph capabilities demonstrated in initial response, generate simulated views of the Orbiter stack as it would appear during a nominal launch, with emphasis on reflections from all known sources of light (i.e., left and right SRB plumes, main engines, and Sun). If task is feasible, the requirement is for a view from each camera location (E207, E204, E217, and E203) for every 10-second interval launch or camera acquisition until launch + 70 seconds. This task would require, for example, only two views E207, those being at 57 seconds and 67 seconds MET.

(2) *USAF—Wright Patterson AFB (WPAFB)*

(a) Detect and quantify motion of right SRB relative to other Shuttle components—Using photo materials and ancillary data, analyze for evidence of motion of the right solid rocket booster with respect to the other Shuttle components. Telemetry evidence suggests that the right SRB broke loose from at least one aft attachment point at approximately 72.5 seconds MET. At some point in the subsequent explosion, the right SRB obviously became completely separated and proceeded through the debris cloud. Any information on the relative attitude of the right SRB to the rest of the Shuttle stack as a function of time would be useful.

(b) Analysis of Right SRB after Explosion—Describe the motion and structural abnormalities of the right SRB after separation from the STS 51-L stack; i.e., Orbiter, SRB's, and ET. Where possible, describe motion in pitch, roll, and yaw. Analyze the imagery to determine size and location of burn through area(s) in the SRB. Locate the burn through area(s) on a CAD/CAM. Use photographs from E207, E206, and E204 to accomplish this task.

(3) *USAF—Space Division*

(a) Development of Flare from Burn Through—Use appropriate frames from E207, E206, E217, E204, and E203 to determine time and location of the initial flare.

Locate point on the SRB in both longitude and circumference. Define growth of flame projected into the X/Z and Y/Z planes, and characterize the apparent progression of origin of flame around the circumference of the SRB. Identify if and when the flame first impinges on the external tank. Is there any evidence of a hydrogen leak from subsequent burn through of the ET? If so, describe the time and development. This analysis is essentially a rerun and expansion of previous analysis, with additional source material.

(b) Cause and Effect Analysis of Explosion — Analyze available imagery and ancillary data from launch through explosion and develop cause and effect scenario to explain the chain of events visible in the imagery. In lieu of a complete scenario, individual observations of features or events that would be significant in a cause and effect investigation would be helpful.

(c) Analysis of Right SRB after Explosion — Describe the motion and structural abnormalities of the right SRB after separation from the STS 51-L stack; i.e., Orbiter, SRB's, and ET. Where possible, describe motion in pitch, roll, and yaw. Analyze the imagery to determine size and location of burn-through area(s) in the burn through area(s) on a CAD/CAM. Use photographs from C207, E206, and E204 to accomplish this task

(4) *Lockheed Missiles and Space Corporation*

(a) Development of Flare from Burn Through — Use appropriate frames from E207, E206, E217, E204, and E203 to determine time and location of the initial flare. Locate point on the SRB in both longitude and circumference. Define growth of flame projected into the X/Z and Y/Z planes, and characterize the apparent progression of origin of flame around the circumference of the SRB. Identify if and when the flame first impinges on the external tank. Is there any evidence of a hydrogen leak from subsequent burnthrough of the ET? If so, describe the time and development. This analysis is essentially a rerun and expansion of previous analysis, with additional source material.

(b) Characterize Smoke at Launch — Using data from CZR-1, E60, and E63, characterize development of the puff of dark smoke between the starboard SRB and the ET shortly after T - 0. Try to define origin and time of first emission. Note that Shuttle stack is oriented with + Z axis north. Sun would be illuminating the space between the SRB and ET from the Orbiter side; thus, a shadowing effect could be evident before actual visibility of the smoke. For reference, time of interest on E60 begins at about frame 1200, with smoke visible in the frame 1235 to 1240 region. Maximum visibility is near frame E60/1350.

(c) Cause and Effect Analysis of Explosion — Analyze series of imagery just before and during explosion and develop cause and effect scenario to explain the chain of events visible in the imagery. In lieu of a complete scenario, individual observations events that would be significant in a cause and effect investigation would be helpful.

(5) *Jet Propulsion Laboratory*

(a) Using frames from E207 centered on time 66.464 seconds MET, characterize the development of the plume. In particular, determine if secondary plume is originating from ET and represents liquid hydrogen or gaseous hydrogen. Determine if hydrogen is burning. Use film from other cameras V.D.8.b.(5)(b) to help in this analysis; i.e., E203, E217, and E204.

(b) Using CZR-1, E60, and E63, determine location or origin of smoke puff present on SRB immediately after lift-off.

(c) Continue development of SRB plume from frame 160 of E207 to point of explosion. Review film to determine if every fourth frame is needed or if less frequent interval would be sufficient. Define when plume impinges on ET.

(6) *ITEK, Inc.*

(a) Time and Origin of Burn Through — Using the appropriate frames from rolls E207 and E203, determine the time and location (on the SRB) of the first burn through. Characterize the orientation and rate of growth until flare is visible from the south on E204.

(b) Growth of Split in Right SRB — Determine radial extent of burn through on the right SRB as a function of time. Use available data before and after the explosion to determine initial growth rate shortly after burn through and the maximum extent evident at the time the right SRB disappears into its own plume shortly after drogue chute deployment.

c. *Results*

The results of these follow-on analyses were received in the mid-March to early-April timeframe and generally have not been analyzed and consolidated for this report. The findings do, however, generally corroborate the integrated timeline events when the analyses pertain to a particular event.

A summary of available results from the other government and industry analysis and enhancement efforts is contained in the following tables (10 through 17).

NPIC enhancements and CAD analyses provided data used to differentiate the developing flare from normal reflections. NPIC generated a CAD model of the external tank and solid rocket boosters and showed a view similar to that seen by E207, emphasizing reflections of light cast by the opposite SRB plume (figure 137). Evidence that a bright spot, as viewed by E207, is a reflection is supported by uniform brightness levels in the sequence of false color images (figures 138 and 139). The brightness of hypothetical reflections (small arrows on the enhancements) remains constant between frames 23 and 109. By contrast, the flare on the opposite side of the SRB (large arrow on enhancements) increases significantly during the same timeframe. This convergence of evidence, using computer models and enhanced photography, was valuable in characterizing the time and origin of the first burn through.

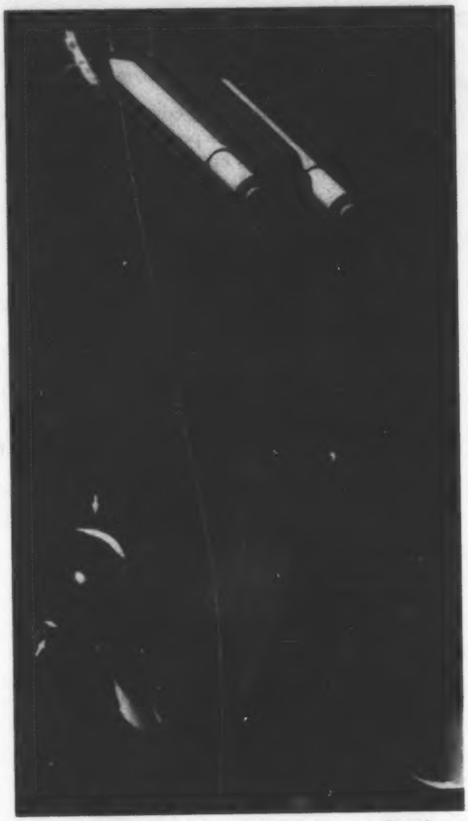
Table 10 Smoke Puff at Launch

Report	*Date*	*Camera*	*MET*	*Description*
KNSC	3/21	E60	0.669	First indication of smoke — visual inspection.
EPRCO	2/25	E60	0.638	First indication of smoke using image enlargement and contrast stretch.

As examples of the work done at the remote laboratories, figures 137 through 139 have been included.

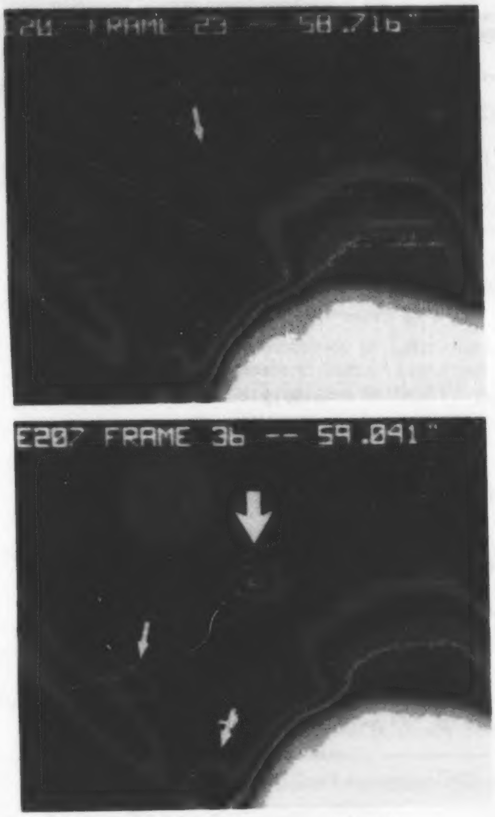
NPIC enhancements and CAD analyses provided data used to differentiate the developing flare from normal reflections. NPIC generated a CAD model of the external tank and solid rocket boosters and showed a view similar to that seen by E207, emphasizing reflections of light cast by the opposite SRB plume (figure 137). Evidence that a bright spot, as viewed by E207, is a reflection is supported by uniform brightness levels in the sequence of false color images (figures 138 and 139). The brightness of hypothetical reflections (small arrows on the enhancements) remains constant between frames 23 and 109. By contrast, the flare on the opposite side of the SRB (large arrow on enhancements) increases significantly during the same timeframe. This convergence of evidence, using computer models and enhanced photography, was valuable in characterizing the time and origin of the first burn through.

FIGURE 137



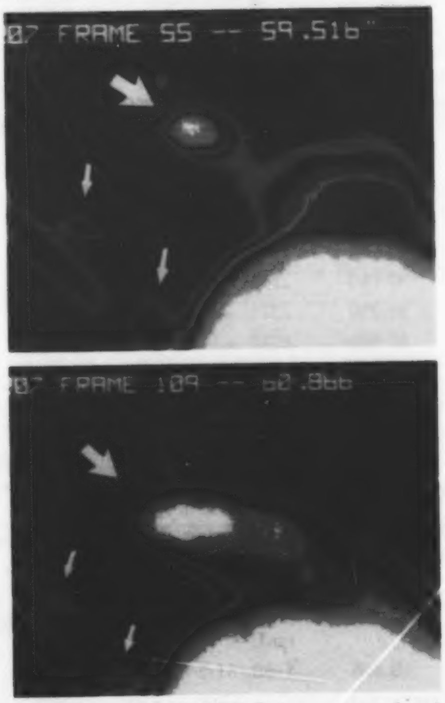
Graphics Display of Light Reflections on Stack.

FIGURE 138


FRAME 23 -- 58.716"
E207 FRAME 36 -- 59.041"

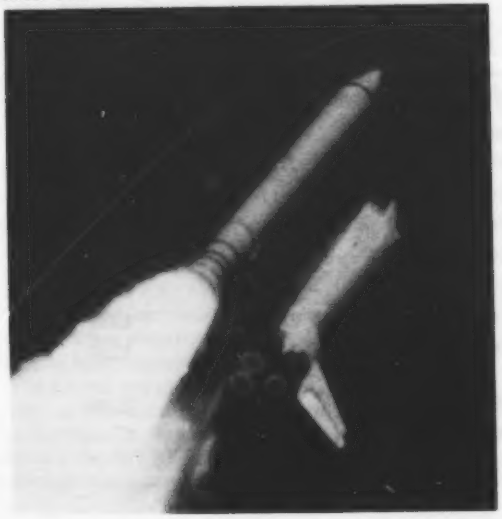
Camera E207 at 58.716 Enhancement (top) and Camera E207 at 59.041 MET Enhancement (bottom).

FIGURE 139


07 FRAME 55 -- 59.516"
07 FRAME 109 -- 60.866

Camera E207 at 59.516 MET Enhancement (top) and Camera E207 at 60.866 MET Enhancement (bottom).

FIGURE 140



Camera E202 at 45.217 MET (above and Annotated Hidden-Line CAD Drawing (right).

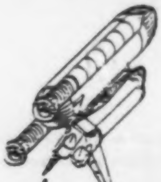


Table 11 First Evidence of Flame on Right SRB

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*
NPIC	2/11	E207	23	58.761	"Light gray wedge shaped area determined as a possible smoke puff appears to emanate from that same region."
JPL	2/17	E207	23 or 24	58.761	"Frame 23 or 24 appears to be the first frame with a reflection of the flame."
LMSC	2/12	E207	23	58.761	"There is evidence in frame 23 (58.716) of a possible flame at that time which is not visible to the camera (i.e., it is bright enough to reflect off of the external tank)."
LMSC	2/12	E207	35	59.016	"Frame 35 (59.016 MET) showed the earliest evidence of a flame." ". . . the specular reflection assumption is probably incorrect."
Other	3/20	E207	12	58.486	"ET is illuminated by an apparent source located on the SRB but obscured from view."
Other	3/20	E207	23	58.761	"Flare is not yet visible."
LMSC	3/21	E207	25	58.811	Reflection
LMSC	3/21	E203	1189	58.814	Direct

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.

As examples of the work done at the remote laboratories, figures 137 through 139 have been included.

Table 12 Continuous Well-Defined Plume

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*
JPL	2/17	E207	52	59.487	Brightness grows continually beginning with frame 52.
Other	3/6	E207	42	59.236	". . . obviously a flame in frames subsequent to 42."

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.

Table 13 Locations of Flame

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*[b]
NPIC	2/11	E207	23	58.761	1253 +/-73 in.
NPIC	2/11	E207	35	59.061	1232 +/-72 in.
NPIC	2/11	E207	36	59.086	1251 +/-73 in.
NPIC	2/11	E207	42	59.236	1272 +/-74 in.
NPIC	2/11	E207	55	59.561	1248 +/-73 in.
NPIC	2/11	E207	96	60.586	1258 +/-73 in.
LMSC	2/12	E207	23-110	58.761	". . . it appears the origin was within one foot of the segment seam."
LMSC	2/12	E207	23-55	58.761	". . . maximum B circumferential extent of the flare (134 deg., or approximately 14 feet)." "The growth stops at approximately 59.5 seconds." ". . . the origin location would be at about 23 degrees toward the external tank."
JPL	3/17	E207	28	58.866	1488, 51.2 deg. toward ET.

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.
[b] Location is referenced to -X axis.

Table 13 Locations of Flame (Concluded)

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*[b]
Other	3/6				1439/1453/Attachment ring. ". . . the source is obscured from view around the side of the SRB." "It is unlikely that the source is very far around from the visible surface."
Other	3/20	E207	12	58.486	Near lower attach strut – XB = 1696
Other	3/20	E207	35	59.061	XB = 1657 + 12 inches; 52 degrees A from + Z toward ET
Other	3/20	E203	1233	60.281	"Orientation of flame changes from frame to frame." From near the lower strut tangent to the ET.
LMSC	3/21				"Close to the aft segment joint" (1491.56 inches.)
LMSC	3/21				53 degrees + / – 6 degrees.
USAF/WPAFB	3/14	E207	27	58.861	0.338 inches + 50 inches.

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.
[b] Location is referenced to – X axis.

Table 14 First Evidence of Plume Deflection

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*
T-LINE	3/14	E207		60.238	First evidence of plume deflection – intermittent.
Other	3/20	E203	1233	60.281	"Orientation of flame changes from frame to frame."
LMSC	3/21	E203	1231	60.2	"First impingement."

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.

Table 15 First Evidence of Continuous Plume Deflection

Report	*Date*	*Camera*	*Frame*[a]	*MET*	*Description*
T-LINE	3/14	E207		60.988	First evidence of continuous plume deflection.
Other	3/20	E203	1247	60.748	"Flame appears to wrap around the aft section of the ET."

[a] Frame numbers were assigned at JSC to facilitate processing. Photographs should be referenced by camera and MET.

Under the assumption that the brightest image area shown at 58.886 seconds MET is indeed the direct image of the flame, the flame source location was identified by projecting a crosshair on the SRB surface at the projected source of the flame. The location identified on the SRB surface is:

$$(X,Y,Z) = (1488,\ -56,\ -45)\ \text{(inches)}$$

This location is, within the accuracy of these measurements, at the SRB field joint which is immediately above the attach ring 3.

The location accuracy is + 4 inches since the pixel size for the image is approximately 4 inches.

The central axis in the X direction of each cylinder (ET, SRB) is used as the reference for the individual Y and Z coordinates. The X reference is the X_t reference for the ET and is the X_{rb} reference for the SRB. The sense for the coordinates is the same as the right-hand sense for the ET and SRB coordinate systems.

Table 16 Motion of Right SRB[a]

Report	*Date*	*Camera*	*Frame*[b]	*MET*	*Description*
EPRCO	2/22	E207		73.150 to 73.161	The right SRB appears to have pivoted and ruptured the ET.
USAF/WPAFB	3/17	E207	578	72.636	The booster (right SRB) exhibits an angular component of approximately 4 degrees in the Orbiter's +Z direction which probably includes an unmeasured +Y component as well.
JPL	3/17	E207	580-599		Two different analyses observed no relative motion.

[a] Telemetry data confirms right SRB relative motion with respect to the stack at 72.201 seconds MET.

[b] Frame numbers were assigned at to facilitate processing. Photographs should be referenced by camera and MET.

Table 17 Postexplosion Right SRB Activity

Report	*Date*	*Camer*[a]	*Frame*	*MET*	*Description*
USAF/WPAFB	3/14	E207	1715-1767	76.414 (1747)	Very gradual end-to-end movement (pitch).
		E206	675-829	74.200-78.050	Roll about the long axis most noticeable from
		E207	658-793	74.650-78.025	E207.
USAF/WPAFB	3/14	E207	708	75.886	A rectangular portion of the nose cone and forward end of cylinder exhibits a blackened tone along the long side and coincident with the SRB axis 150 inches from nose tip, 242 inches × 60 inches in area.
USAF/WPAFB	3/14	E207	729	76.411	Event signals the start of nose cap separations.
		E207	744	76.786	Pilot chute first observed.
		E207	756	77.086	Drogue chute initially deployed.
		E207	787	77.861	Chute reaches full deployment.
USAF/WPAFB	3/14	E207	707-716	75.861-76.086	Edge of plume 1194 inches from tip of nose cone with the center at 1430 inches. Size could not be estimated.

9. Flashes Downstream of Orbiter Right Wing

Photography of the STS 51-L ascent through 58 seconds was analyzed for anomalous events. Photographs from cameras at locations to the north, south, east, and west of the launch pad were reviewed. Two of these cameras, E217 and E202, recorded flashes downstream of the Orbiter right wing.

Mission elapsed time: 45.217, 48.118, and 48.418 Source: Camera E202 and PLAIDS hidden-line CAD drawing

At 45.217 seconds MET, the E202 camera recorded the first flash downstream of the Orbiter right wing (see figure 140). The E202 camera recorded a second and third flash downstream of the Orbiter right wing at 48.118 seconds MET and at 48.418 seconds MET, respectively (see figures 141 and 142). An additional flash also appears to have been recorded on E202 at 48.384 seconds MET. This flash is not as intense as the previous three and may be a precursor to the one seen at 48.418 seconds MET. In addition to the flashes seen on E202, two flashes were observed on E217 in the corresponding timeframes. The first is observed at 44.2 seconds MET and the second at 47.4 seconds MET. Hidden-line CAD drawings of each of the three flashes accompany each picture to show the flash in relation to the vehicle.

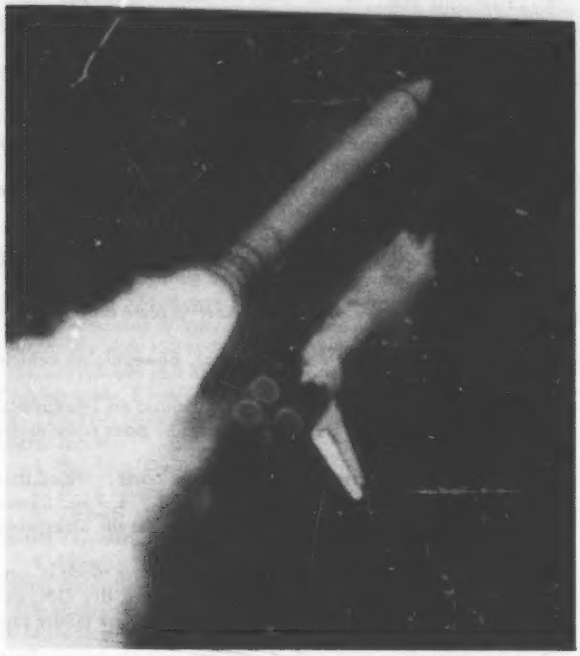
This phenomenon has also been observed on other flights during which no serious anomalies occurred; therefore, these flashes are considered nominal events.

E. OTHER OBSERVATIONS

Several film observations have been deemed noncontributory to the STS 51-L incident by the Photo Team, but will be addressed in this section since many outside observers have requested interpretations. The first of these observations is of two bright spots visible during flight and shown in figure 143. These spots are reflections of the SRB plumes off of the Integrated Electronics Assembly (IEA) box of the SRB and the "stinger" on the OMS pod of the Orbiter. These are typical of previous flights and are simply a result of vehicle geometry.

The next observation is of "further smoke from the RSRB." This is really a series of reported observations at various times during flight and is a result of the usual presence of smoke in the vehicle base region. This typical smoke is due to outgassing and ablation of the ET and SRB insulation materials. From some camera views, it does indeed appear that smoke is in the RSRB aft joint area at a given time; however, this is due to the angle of observation, the smoke is really not coming from the joint. In the top photo of figure 144, the SRB rings are visible through the plume, while in the bottom photo the plume obscures the rings. Careful review of films from various angles by experienced and knowledgeable photo interpreters has led to the determination that no smoke from the joint area is visible after 3.375 seconds.

FIGURE 141



Camera E202 at 48.118 MET (above) and Annotated Hidden-Line CAD Drawing (right).

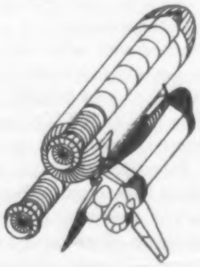
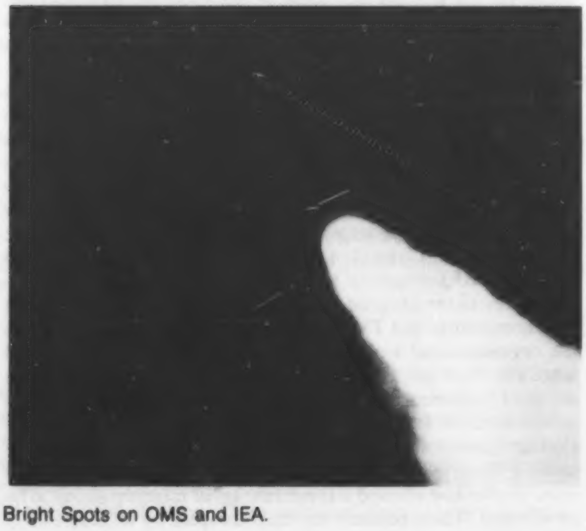
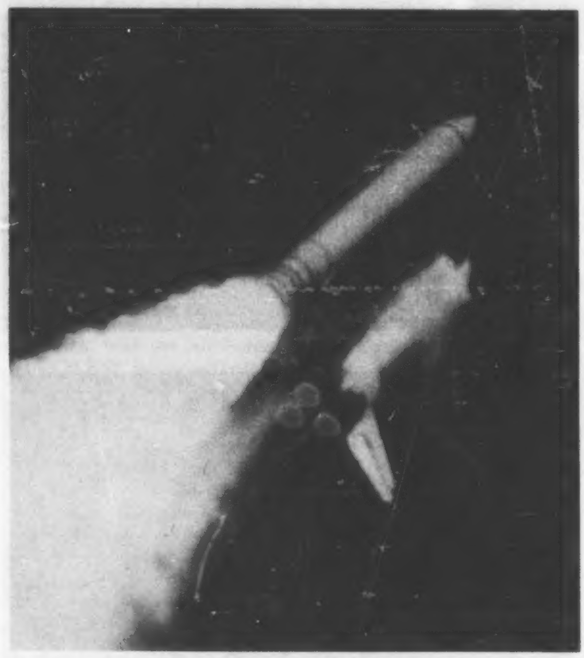


FIGURE 143

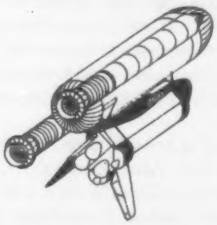


Bright Spots on OMS and IEA.

FIGURE 142



Camera E202 at 48.418 MET (above) and Annotated Hidden-Line CAD Drawing (right).



Another observation was of an "orange finger of flame" which appears on the NASA select video which was broadcast by the networks on the day of launch and appeared to emanate from the SSME's. This phenomenon starts at approximate 60 seconds into flight and is simply contamination of the SSME plumes due to the effluent from the SRB leak which, due to the camera angle gives the appearance of coming from the SSME area.

VI. FINDINGS & CONCLUSIONS

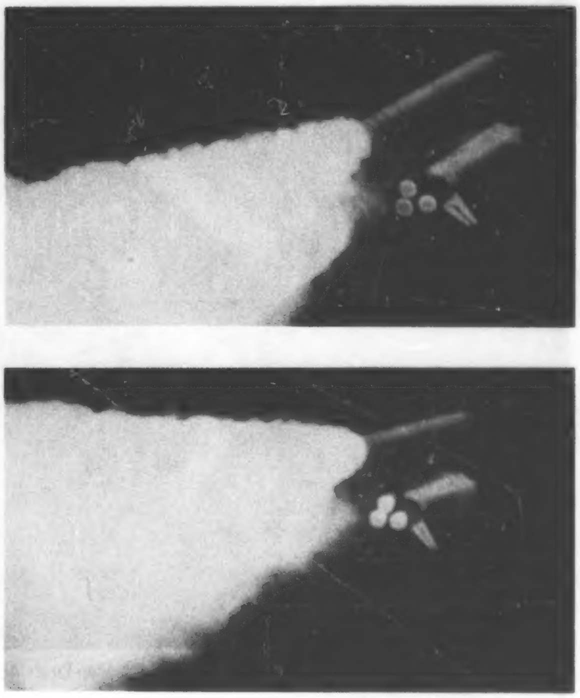
A. Introduction

In a contingency situation, the visual information can be an extremely important source of data. This was certainly the case in the STS 51-L incident in which events leading up to the incident were external to the vehicle and open to view; furthermore, the clear, cloudless atmospheric conditions allowed the failure development to be clearly visible from the ground.

In spite of the loss of data from several key camera locations, film data provided early pivotal clues that enabled the investigation to focus on the cause of the accident and later made substantial contributions toward understanding the failure.

It is important to emphasize that the clear-day weather and the resulting imagery collected were very significant in the acci-

FIGURE 144



E217 at 41.832 MET (top), E217 at 45.498 MET (bottom).

dent analysis investigative work. Had it been a night launch or a launch with a low overcast sky, the amount of time required to reach the conclusions drawn would have been much greater and perhaps never as clearly understood. In the case of STS 51-L, photographic data were not merely a backup for other instrumentation, they were primary.

B. Findings

The findings listed below are the result of the analysis performed and described in this report.

1. After a thorough review of all photographic and video products available from the flight, the anomalous imagery can be summarized into the following seven major categories:

a. The appearance of smoke at 0.678 second MET in the near vicinity of the RSRB aft field joint located radially approximately 300° to 315° from the +Z axis (clockwise). The last positive visual indication of smoke dispersing below the ET aft dome occurred at 3.375 seconds MET.

b. The appearance of a continuous well-defined anomalous plume on the RSRB in +Z, −Y coordinates at 59.262 seconds MET.

c. A LH_2 tank leak occurred near the ET 2058 ring frame at 64.660 seconds MET.

d. The aft end of the RSRB broke away from the ET at approximately 72.201 seconds MET.

e. LH_2 tank failure occurred near the 2058 ring frame at 73.124 seconds MET.

f. LO_2 tank failure occurred at approximately 73.162 seconds MET.

g. Vehicle structural breakup occurred at approximately 73.327 seconds MET.

2. Closeout photo analyses of the STS 51-L right SRB aft field joint confirmed that the O-ring did not have any defects prior to mating of the joint in the vicinity of the suspect failure point.

3. No anomalous motions (twang) were observed during the SSME ignition and lift-off time frame.

4. Pad photography confirmed:

a. A problem with the hydrogen vent arm retract latchback mechanism.

b. Liquid oxygen T-0 umbilical carrier plate motions were nominal.

c. Facility ice debris was significant, however, no vehicle anomalies resulted.

d. A dark fluid (H_2O) coming from behind an I-beam and kick plate adjacent to the ET gaseous vent line pivot point at the 220 ft. elevation.

5. Postlaunch inspection of the holddown posts revealed that the kickspring assemblies on holddown posts M-3, 4, 7 and 8 were missing. There is no photographic evidence that the kickspring assemblies impacted the vehicle.

6. Eleven photo cameras failed. Primary failure mode is considered to be brittleness as a result of prolonged dry GN_2 exposure and extreme temperature. The normal camera failure rate experienced has been 2 to 3 per mission.

C. Lessons Learned

1. Organization

Immediately after the STS 51-L incident, substantial efforts were begun independently at the three concerned NASA Centers (JSC, KSC and MSFC).

The JSC & MSFC Center Teams worked within the charters of their Center contingency plans. At KSC, the Level II TPS Ice Frost/Debris Team was chartered by the NASA Interim Mishap Investigation Board to be the Photo Analysis & Review Team. Coordination of these activities was limited and communication of results and sharing of image analysis products were a problem because of security constraints, geographical separation of activities, obsolete or inadequate facilities and equipment and the overwhelming magnitude and urgency of the activities. There were some improvements as the situation settled down; however, there was a substantial improvement after the Task Force was formed and the Photo and Video Analysis Team chartered and given responsibility for analysis of imagery.

Internal organization and lack of necessary activities at the Centers created start-up problems and inefficiency which hampered the early efforts. At JSC, there was no image analysis in place at the time of this incident although there were experienced personnel. At MSFC, there was image enhancement activity, but it had not been used in postflight analysis and it was physically and organizationally separated from the group which this work. At KSC the photographic functions were fragmented and scattered throughout the Center.

The key to the progress made in photo analysis from the time the Photographic and TV Support Team was established has been the organizational structure of the team. Common goals and schedules were set, events of interest were selected, roles were assigned, common imagery was defined and common or compatible methods for its analysis established. Analysis products including enhancements were reviewed by the group and interpretation was done as a group which minimized differences in conclusions drawn and allowed a consistent set of interpretations to be established. These results were then accepted by all elements of the investigation as definitive of the visual events of the incident.

The success of this organizational approach indicates that a similar approach should be taken for any future incident. To assure that this is the case, a chartered intercenter Photographic and TV Analysis Team should be included in the NASA contingency plan and subordinate activities at JSC, KSC and MSFC should be made part of the contingency plans at these Centers.

2. Facilities and Equipment

a. *Photographic Cameras and Film*

Somewhat outdated optical systems for many cameras included only fixed focus lenses. Some imagery was out of focus and lacked detail. This caused small format (16mm) films to be difficult to use for anything other than event timing and gross feature identification; 35mm and 70mm films were markedly superior for precise location of features and for use in enhancements. These cameras are slow (20 to 96 frames per second), whereas 16mm cameras typically run at 400 frames per second and are capable of higher rates. Evaluation of motion picture imagery from mission STS 51-L indicates that precision analysis was inhibited by several factors:

1. Solution/acuity.
2. High noise/granularity.
3. Density clipping of highlights and shadows due to the limited exposure latitude of the camera film.
4. Quality transfer loss on the duplicate prints due to the limited resolution of the print film.

The analysis of imagery from mission STS 51-L, indicates that the latitude limitations of the film prevented the recording of details in the shadow areas including that of the smoke plume as well as a loss of detail in the overexposed highlighted areas such as primary and reflected flame areas. The resolution limitations and higher noise (grain) limited the analysis of detail from high magnification prints.

Several questions were raised during the investigation regarding flame or skin temperatures which could not be answered using the type of film used for launch photography. Black and white film would be more useful where extreme resolution is important, as in determining the location and dimensions of features such as plumes and joint leaks. The camera film breakage rate was responsible for missing the location of a key event, the actual emission of the smoke puffs. Although the location was inferred from images from cameras in other locations, a great deal of extra work was involved in so doing as well as in convincing other investigators of the accuracy of the inferred position. More reliable equipment and better thermal conditioning are in order. Camera positions should be reviewed to ensure overlapping coverage to eliminate blind spots between camera positions.

The need for alphanumeric frame number and GMT as well as an initialization "slate" of film and camera data on all film products was apparent during this investigation. Due to the lack of time displacement markings on some of the films, large efforts were required to establish timing of significant events and wrongly identified frames were, at times, used in scenario development. Digital timing can be placed on film frames. Excellent systems are available to perform this function. If costs of this system are considered to be too high, then all of the cameras should be equipped with a timing index.

b. *Television*

Television coverage of this incident was useful in developing many of the early conclusions about the failure. Lack of timing on some of the video made it difficult to compare with tracking film data. The video systems should be upgraded to include timing. The state-of-the-art in television is improving with the availability of CCD (charge coupled devices) and HD (high definition) color TV cameras. These cameras eliminate the scan-line irregularities and image blurring which make it difficult or impossible to locate features precisely with video. The television equipment state-of-the-art should be followed very closely with the goal of updating the OTV system.

c. *Support Facilities and Processes*

The large volume of photographic and video material generated in the accident investigation placed a severe load on the KSC processing system. Several areas need improvement. The photo analysis equipment, which is obsolete and requires frequent repair and maintenance, is located in crowded and unsuitable facilities. The processes are labor intensive, particularly manpower levels. The photographic support contract is mostly funded by NASA, but is managed by the Air Force. Most of the photo facilities are located on Air Force installations, making access and transport difficult especially during contingency operations. The entire arrangement with the Air Force should be reviewed with the objective of KSC being self sufficient. A review of the Shuttle Processing Contractor role in closeout photos needs to be made. Additionally, KSC needs to have a centralized focused photographic and TV organization and not be fragmented between several organizations.

A controlled archival storage of photographic and video originals, master copies of films, and derived products is required at KSC. This investigation highlighted the need for comparison with previous flight imagery. Material dispersed from KSC to the other Centers needs to be retained and stored at a central location designed for that purpose. No common photographic cataloging and data transfer system exists between Centers, and one should be developed.

There was no capability at KSC for required digitization of film to provide suitable products for digital enhancements. Suitable systems were in place at JSC and MSFC, but high quality products were not made available to these Centers initially. Furthermore, there are no capabilities for secure transmission of digital products between Centers. These problems can be solved readily by upgrading facilities and establishing secure communication networks.

Finally, the systems in place at the three Centers have not been selected for compatibility. Although, it is unnecessary that all Centers have the same equipment or that each of the Centers be able to perform any of the necessary functions, a review needs to be made of the existing capabilities with the goal of enhancing compatibility.

d. *Techniques*

Prelaunch closeout photographs document the as built configuration of the vehicle. The photos are taken to show overall and closeup views of particular areas, as required. The data provided by these photographs is primarily used by engineering to compare the closeouts to drawing requirements. The closeout photographs are not intended to record data for precise measurements or enhancement as demanded by a contingency situation. However, the quality of closeout photographs could be improved by using experienced photographers rather than hardware inspectors.

This investigation revealed a need for advanced techniques in image analysis and enhancement. Methods for temperature determination, constituent analysis and compensation for atmospheric effects would be useful as well as the use of CAD/CAM systems with computer generated imagery and feature measurements. As an advanced tool, the constituent analysis may have contributed significant data to the smoke composition or liquid hydrogen leak theories.

D. Conclusions

1. A contingency plan is required for imagery which calls out an intercenter organization with named chairmanship and membership with a charter parallel to that of the other teams in the NASA contingency plan. Air Force participation would be helpful.

2. At the concerned field centers (JSC, KSC, MSFC) photo contingency teams are required which are parallel to those of the teams currently in Center Contingency Plans.

3. NASA should have a self-sufficiency objective for a total end-to-end photographic and TV products analysis capability. This includes from the initial acquisition of the product through a report writing conclusion capability. Utilization of other Government facilities should be for special project work only. Cost tradeoffs can be performed to help draw the practicality line. This recommendation is intended to be for an agency program capability and is *not* intended to promote needless redundancy within the STS program.

4. Procedures are required for film review and processing, dissemination of master copies, image analysis and enhancement for use in failure investigation.

5. Common photographic cataloging, communication and data transfer systems between Centers is required.

6. A controlled archival storage system for launch photographic and video original material is required at KSC.

7. A study should be conducted through the intercenter organization and center teams of the future engineering data and analysis required and procedures to be followed for accident prevention purposes and contingency accident investigation at KSC and VAFB. The study should include a review and selection of optics, cameras, film exposures, selective filtering including downrange haze penetration, removal of uncovered blind spots at launch, and coverage for orbit and landing phases.

8. Improve the quality and documentation of closeout photographs by using experienced photographers rather than hardware inspectors with limited photo training experience.

9. Flight hardware paint patterns are required.

10. Include alphanumeric display of frame number and standardized timing on each frame of film and video.

11. A review of the state-of-the art equipment should be made to implement the best capability for engineering analysis purposes.

12. Augment and maintain image analysis and enhancement efforts within the Agency to ensure adequate capabilities.

13. Establish a KSC engineering photographic analysis lab with state-of-art equipment.

14. A capability for making color reversal prints should be established at KSC.

15. There should be an improvement in lighting, especially at night, of critical areas such as the holddown posts on the pad.

APPENDIX A

1. Photo-Optical System Description

This section briefly describes and outlines the operational capabilities of the launch operations area (LOA) photo-optical system used at KSC. The subsystems that make up the LOA photo-optical system are listed in the following table.

LOA Photo-Optical System

System Equipment	*Model*
LC-39A Launch Control Center	U72-1159
LC-39A pad, fixed service structure, and perimeter	U72-1042
Mobile launcher form (MLP)	U72-1072

Figure 145 shows the location of all cameras on the MLP and fixed service structure, and table 18 lists pertinent camera and film data for the MLP and FSS cameras. All of the technical documents/drawings (maintained and nonmaintained) associated with the LOA photo-optical system are listed in the System Documentation List, 79K11142, which serves as the top Operation and Maintenance Documentation system definition drawing. This list identifies the specific documents/drawings that comprise the maintained Operation and Maintenance Documentation.

The function of the LOA photo-optical system is to operate still and motion picture film cameras located at various areas on launch complex 39 (LC-39). The system consists of equipment located in the following areas: Launch Control Center (LCC) room 1P6, pad A and pad B, pad terminal connection room (PTCR) room 207, FSS, MPL, and at the pad perimeter camera sites. The system consists of the following subsystems:

LCC camera control system
Pad camera control system
Timing system
Emergency camera control system
Power subsystem
Camera mounting system
Gaseous nitrogen (GN_2) purge system

Two camera trackers are located on LC-39: one on perimeter camera site 2 and one on perimeter camera site 6; these trackers are remotely controlled from room 1P9 of the LCC.

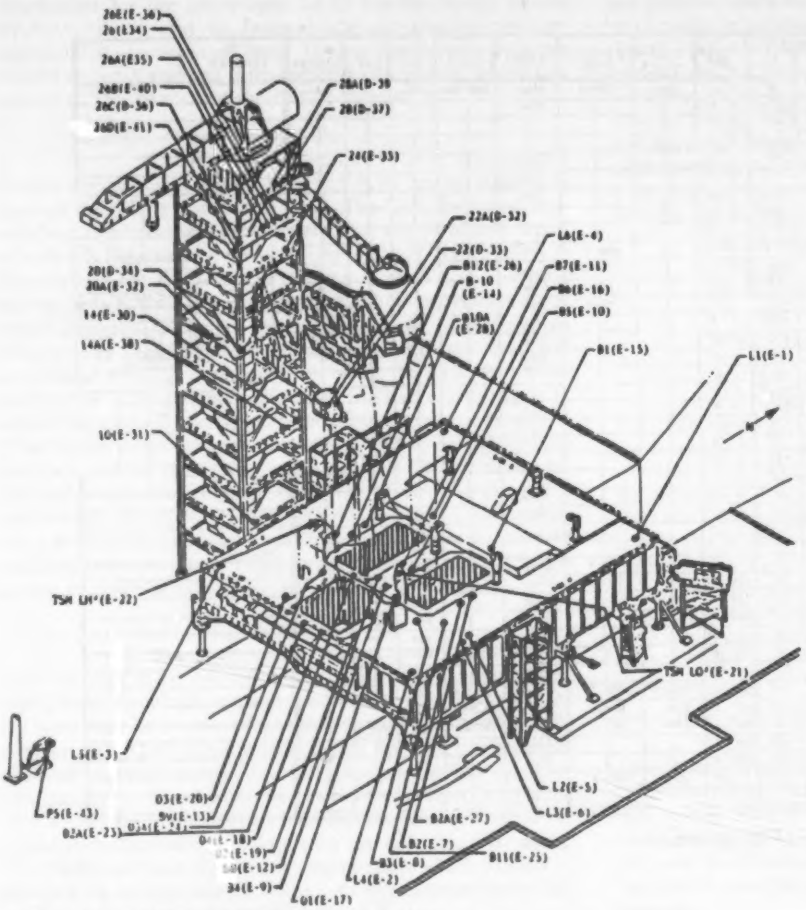
a. *System Components*

(1) *LCC Camera Control Systems*

The two LCC camera control systems have the capability of initiating 320 control (on-off) signal "starts" over 320 channels. LCC camera control systems 1 and 2 have 160 channels each. The control signals can be automatically initiated simultaneously or sequentially at predetermined intervals or started manually. The photo-optical system is basically automatically sequenced with provisions for manually overriding the automatic control. Each LCC camera system consists of the following components:

Camera control panels
Camera control patch panels
Camera control sequencer and sequencer control panel
Sequencer synchronizer control panel
Events programmers and patch panel
Control multiplexers
Status demultiplexers
Wideband line patch panel

FIGURE 145


26E(E-36)
26(E34)
26A(E35)
26B(E-40)
26C(D-36)
26D(E-41)
28A(D-38)
28(D-37)
24(E-33)
22A(D-32)
22(D-33)
B12(E-26)
B-10
(E-14)
B10A
(E-28)
L6(E-4)
B7(E-11)
B6(E-16)
B5(E-10)
B1(E-15)
L1(E-1)
20(D-34)
20A(E-32)
14(E-30)
14A(E-38)
10(E-31)
TSM LH*(E-22)
TSM LO*(E-21)
L5(E-3)
P5(E-43)
O3(E-20)
9V(E-13)
O2A(E-23)
O4(E-18)
(E-19)
(E-12)
34(E-9)
O1(E-17)
L4(E-2)
B3(E-8)
B2(E-7)
B2A(E-27)
B11(E-25)
L2(E-5)
L3(E-6)

General View of FSS and MLP Camera Locations.

Emergency camera control (ECC) panel
ECC distributor and patch panel
ECC firing room (FR) selector panel
Firing room ECC panel
Power supplies

(a) *Control Signals*

The photo-optical system camera control signals can be automatically sequenced into 100 start and stop times, which are turned on and off at preselected times by the camera control sequencer. The camera control sequencer feeds the control signals in parallel form to eight multiplexers. The multiplexers serialize the control signals into return-to-zero (RZ) data trains, which are fed to data modems. The data modems convert the signals into a dc level shift data train which is distributed to the demultiplexers. Each multiplexer/demultiplexer (mux/demux) channel sends 40 lines of on-off information used to energize relays in the camera control repeaters (CCR's) which apply power to the camera motors.

(b) *Camera Control Panel*

The photo-optical system has 16 camera control panels in the LCC at LC-39. Eight camera control panels are for LCC camera control system 1, and 8 camera control panel were for LCC camera control system 2. Either camera control system may be used, with appropriate patching, to control either pad A or pad B. Each of the camera control panels has 20 three position switches which are used to initiate the camera control signals. The switch positions are SEQ ON, OFF, or MAN ON.

– SEQ ON position provides -28 V dc enable voltage to the camera control sequencer and allows the channel to be turned on and off at the programmed time.

– OFF position inhibits the channel, except that the emergency camera control subsystem can turn the channel on with the switch in this position.

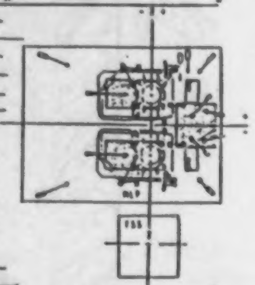
– MAN ON position is the manual override.

– The camera control panels used for each LCC camera control system are identified with camera channels and are numbered from top to bottom and left to right with numbers 1 through 160. The camera control panel three position switches are backlighted with colored filters for the following three positions:

– MAN ON (up) position – red OFF
– (center) position – white
– SEQ ON (down) position – green

The lamps are lighted when there is a status output from the status demultiplexer, thus indicating that ac voltage is present at the output of the unique camera control repeater serving a given camera.

TABLE 17

CAMERA	LOC	COORDINATES				ANGLES		HGT	FILM SIZE	CAMERA TYPE	LENS	FILM	FPS	EXP	TIMING	REMARKS
		+Y	-Y	+Z	-Z	AZ	EL									
B1(E-15)	MLP	21'-0"	—	—	41'-7"	0°	0°	5'-6"	16mm	DBM-4	15mm	200'VHO	400	—	A	
B2(E-2)		37'-0"	—	—	10'-6"	7.5°	+11.5°	0'-9"			10mm					
B3(E-8)		32'-0"	—	10'-6"	—	36°	+8°	1'-8"								
B4(E-9)		5'-0"	—	9'-9"	—	9°	+3.5°	1'-8"								
B5(E-10)		5'-0"	—	—	10'-6"	6°	+8°	0'-10"			10mm					
B6(E-16)		—	21'-0"	—	41-7"	0°	-5.5°	5'-4"			15mm					
B7(E-11)		—	5'-0"	—	10'-6"	8.5°	+4.5°	0'-9"			10mm					
B8(E-12)		—	5'-0"	9'-9"	—	9.5°	+4.5°	1'-8"								
B9(E-9)		—	37'-0"	9'-9"	—	38°	+7.5°	1'-9"								
B10(E-14)		—	37'-0"	—	10'-6"	17.5°	+9.5°	0'-9"		DBM-4	10mm				A	
B11(E-25)						26°	+19°	4'-3"		LOCAM	5.6mm				B	
B12(E-26)						15°	+22°	4'-3"		LOCAM	5.6mm				B	
L1(E-1)		62'-6"	—	86'-4"	—	25°	+12°	1'-9"		DBM-4	10mm				A	
L2(E-5)		59'-6"	—	11'-6"	—	3°	+20°	1'-9"			10mm		400			
L3(E-6)		60'-6"	—	16'-6"	—	2°	+30°	1'-10"			25mm		200			
L4(E-2)		62'-6"	—	53'-0"	—	42°	+9°	1'-6"			10mm		400			
L5(E-3)		—	57'-6"	53'-0"	—	52°	+12.5°	1'-6"								
L6(E-4)		—	62'-6"	—	86'-4"	22.5°	+12.5°	1'-7"								
O1(E-17)		16'-9"	—	14'-6"	—	0°	+53.5°	2'-4"								
O2(E-19)		21'-0"	—	45'-0"	—	45°	+30°	1'-10"								
O3(E-20)		—	21'-0"	45'-0"	—	48°	+26°	1'-11"								
O4(E-18)		—	16'-9"	—	14'-6"	0°	+55°	2'-5"								
O2A(E-23)		2'-10"	—	56'-4"	—	12°	+32°	2'-0"			25mm					
O3A(E-24)		—	2'-10"	56'-4"	—	6°	+30°	2'-1"			25mm					
B2A(E-27)		17'-7"	—	—	13'-6"	32°	-6°	4'-11"			15mm					
B10A(E-28)		—	17'-7"	—	13'-6"	32°	4.5°	4'-10"					400			
1SM(E-22)						7°	7°						200			LH2
1SM(E-21)						7°	7°			DBM-4	15mm		200	—	A	LO2
10(E-31)	FSS	—	76'-6"	19'-0"	—	0°	+25°	105'-4"		DBM-5	25mm		100	AEC	B	
14(E-38)		—	75'-10"	—	6'-0"	2.5°N	-20°	145'-6"			10mm		400	—	A	
20A(E-32)		—	72'-5"	27'-3"	—	1°N	-52°	204'-3"			25mm		200	AEC		
24(E-33)		—	75'-11"	—	11'-6"	1°S	-15°	245'-0"			100mm		400	—		
26(E-34)		—	75'-9"	3'-1"	—	2°S	-60°	264'-9"			15mm		400			
26A(E-35)		—	75'-8"			8°S	-12°	265'-0"			15mm		400			
26B(E-40)		—	75'-5"	3'-8"	—	0°	-62°	264'-10"	16mm	DBM-5	10mm	200'VHO	400		A	
26C(D-36)		—	73'-8"	—	25'-9"	1°N	-45°	265'-3"	35mm	NIKON	20mm	250VPS3	R2		—	
26D(E-41)		—	75'-0"			12°N	-36°	262'-1"	16mm	DBM-5	10mm	200VHO	400	AEC	A	
26E(E-36)		—	76'-6"	—	6'-0"	2°N	+12°	265'-2"			15mm		400	—		
28(D-37)		—	74'-4"	—	29'-8"	12°N	+20°	291'-0"			10mm		48	—		
P1(E-43)	PAD					4.5°NI	+21°	3'-10"	16mm	DBM-5				—	A	

Pertinent Camera and Film Data for MLP and FSS Cameras.

(c) *Camera Control Sequencer and Sequencer Control Panel*

Each photo-optical camera control system utilizes a photo-optical system camera control sequencer—Astrodata model 6575-523-1. The camera control sequencer consists of up-down counters and logic circuitry used in conjunction with the event programmers and patch panel to turn the camera channels on and off. The sequencer control panel contains the events patch panel. The events patch panel has two jacks wired in parallel for each event and camera channel. This configuration allows "daisy chain" patching; all channels patched to a single event will be started and stopped at the same time.

(d) *Events Programmers and Patch Panel*

Each photo-optical camera control system has two events programmers and one events patch panel. One programmer in each camera control system is designated as "continuous" and controls events 1 through 25, and the other programmer is designated "discontinuous" and controls events 26 through 50. A hold in the sequencer count will turn off a "discontinuous" event, but a hold will not turn off a "continuous" event. The events programmer has two sets of thumbwheel switches for each event to establish the start time and stop time for each event. With the event programmer thumbwheel switches set for a start time and a stop time for an event and when the sequencer countdown time reaches the thumbwheel setting for start time, the event is turned on. When the countdown time reaches the thumbwheel setting for a stop time, the event is turned off. An event can control any number of channels as determined by patching at the events patch panel.

(e) *Control Multiplexers*

Each LCC camera control system uses four Astrodata model 6555-516-1 control multiplexer/status demultiplexers for both command and status functions. The control multiplexer serializes the on-off information (40 lines) received from the camera control panels and camera control sequencer. The control multiplexer generates a 48-bit data word which contains 7 bits for frame reference, 1 bit for loop check, and 40 bits of camera on-off information. The 7-bit frame reference is a self-check feature design to prevent noise from interfering with normal control-circuit operation. Each frame reference is compared with the preceding frame reference and must be its complement; if it is not its complement, then the multiplexer will not transmit any camera control data.

(2) *Timing Subsystem*

The timing subsystem includes the timing distributor, a timing terminal unit, and associated cabling. Timing signals are applied to each engineering camera so that time correlation of the exposed film may be identified. The serial timing inputs are applied to an illumination block where a standard Inter-Range Instrumentation Group (IRIG) format timing code is exposed on the edge of the moving film.

(a) *Timing Distributor Panel*

The timing distributor serves as the monitor and distribution for the photo-optic IRIG bipolar timing signals (IRIG-A, -B, -H, and -E). Jacks are also provided for monitoring the CCR control input lines. Timing distributor panels are located at pad A and pad B perimeter B site camera timing and control (CTC) boxes and the PTCR-B room 207.

(b) *Timing Terminal Unit*

The timing terminal unit (TTU) accepts IRIG bipolar-timing coded signals from the KSC timing subsystem through the timing distributor panel. The TTU circuitry processes and converts the bipolar signals into a dc level-shift signal of sufficient amplitude to drive a light-emitting diode (LED) in the camera. This LED exposes the edge of the film to the coded timing signals. An LED monitor on the TTU provides a meter which indicates the current being drawn by the LED. Switches are provided to select the camera channel being monitored and to monitor the LED currents. Each of the ten LED driver circuits in the TTU produces no output until an enable signal (a ground) is received from its corresponding channel in the CCR. (The "enable signal" is simply providing a path to ground through a set of normally open (NO) contacts in the CCR.) Normally, the enable signal is generated in the CCR when the channel is activated by the camera control system. A switch is also provided on the TTU to operate the enable signal internally for checkout and calibration purposes. TTU circuitry power is furnished from a plug in power supply mounted on the TTU chassis.

(c) *Control Demultiplexers*

The photo-optical system control demultiplexer is contained in the Astrodata model 6555-515-1 camera status multiplexer/demultiplexer, and the status multiplexer is part of the same unit. The control demultiplexer converts the pulse code modulation (PCM) signal received from the data modems into 40 on-off signals in parallel form after having verified the frame reference word. The demultiplexer outputs (40 lines) are routed with a -28 Vdc line from the demultiplexer/multiplexer power supply to the camera control repeaters via the buffer relay panel. The CCR's use these signals to energize relays which connect ac power to the camera motors. A ground on the demultiplexer output line will energize the CCR relay.

(d) *Camera Control Repeaters*

The photo-optical system camera control repeaters are two types: single-phase Astrodata model 6550-547-1 which will operate ten single-phase cameras; and three-phase Astrodata model 6550-548-1 which will operate five three-phase cameras. The CCR connects single-phase or three-phase ac power to the camera motors when a start signal is received from the control multi-plexer. The CCR generates the status signal inputs and sends the signals to the status multiplexer. The CCR also furnishes an enable signal to the TTU which turns on the timing signal to the camera. The CCR can operate cameras locally by switches on the CCR front panel, or the CCR can be programmed so that the cameras can only be operated remotely.

(e) *Status Signals*

The photo-optical system status signals are generated in the CCR. The logic term senses the presence of 120 Vac across the circuit supplying voltage to the camera motor winding when the channel is on. The logic term is routed to the status multiplexer, and a status output signal is generated in the status multiplexer output.

The status signals activate lamp drivers in the LCC status multiplexer which turn on lamps in the camera control panel switches. The console operator, by observing the lights and switch positions, can determine when and where the cameras are running. The status signals are transmitted to the LCC by standard communications cables.

(3) *Emergency Camera Control Subsystem*

Each emergency camera control (ECC) subsystem (one per photo-optical system) provides for overriding the camera control system by turning on all channels selected for emergency "starts" with one switch located on pad safety consoles in firing rooms 1 and 3. Once actuated, the ECC subsystem will keep the emergency cameras running for either one minute (mode II) or 15 minutes (mode I), depending on which mode is programmed and assuming the switch remains in the start position. At the end of the programmed ECC cycle, control of the camera channels is returned to the camera control system. Each ECC subsystem includes the following units:

ECC mode selector panel
ECC FR selector panel
2 ECC distributor and patch panel ECC power supply
Firing room ECC panel

(a) *ECC Mode Selector Panel*

The ECC mode selector is on a panel located in LCC room 1P9. The MODE I/MODE II switch provides for the 1-minute or 15-minute emergency-run cycle. In mode I, the cameras run for 15 minutes and stop automatically; in mode II, the cameras will run 1 minute and then stop automatically. A READY indicator lights when the ECC system is enabled by turning on the ECC power supply. The EMERGENCY indicator flashes at 2 pulses per second (PPS) when the selected cameras are activated in a firing room by the START/OFF switch on the ECC panel. Once activated, the EMERGENCY indicator will flash until extinguished by the RESET switch (provided that the START/OFF switch on the FR ECC panel is returned to the OFF position).

(b) *ECC FR Selector Panel*

The ECC FR selector is used to select one of the firing rooms for operating the emergency cameras at the pad areas. When the system 1 DISTRIBUTOR switch is in the FR 1 position, firing room 1 has control over the designated system 1 cameras; when it is in the FR 3 position, firing room 3 has control over these cameras. The system 2 DISTRIBUTOR switch operates in a similar manner for designated system 2 emergency cameras.

(c) *ECC Distributor*

Distributor contains the relay logic for control of the designated emergency cameras. This distributor is equipped with indicators which display the mode position in programmed to operate to indicate when dc power is applied to the subsystem and to indicate when the emergency cameras are running by flashing the EMERGENCY light. This flashing light can be turned off only by actuating the RESET switch on the ECC mode selector panel or by turning off the ECC power supply.

The ECC distributor emergency light is wired in parallel with the ECC mode selector panel emergency light (will operate simultaneously). The ECC distributor contains the matrix board used to patch the selected emergency cameras. Pin plugs are provided for insertion in any of 160 jacks on the matrix board which represent up to 160 camera channels at the multiplexers. Placing a mode I pin in any of the matrix jacks will cause that channel/camera to turn on and off when emergency mode 1 is switched. Mode II pins work in the same manner for emergency mode II operation and also turn on all mode I cameras.

(d) *ECC Power Supply*

The ECC power supply provides power for the entire ECC system. The power supply panel contains two power supply modules which provide redundancy in case one of the modules fails. The outputs of each supply are routed to a diode gate in the ECC distributor which allows one or the other supply to provide power. Indicator lights on the power supply front panel show which supply is supplying the subsystem power.

(e) *FR ECC Panel*

ECC panels are located on the FR pad safety consoles in firing rooms 1 and 3. This panel contains the switch which activates the ECC subsystem. Included on this panel are indicators showing READY (dc power on), mode I or mode II (the operational mode of the ECC subsystem), and RUNNING (emergency).

(4) *Power Subsystem*

The power subsystem consists of the ac power panels, circuit breakers, ac strips, and power cabling. Single- and three-phase fuse panels provide protection for camera motors. Single-phase fuse panels are in series with single-phase CCR outputs, and three-phase fuse panels are in series with three-phase CCR outputs.

(5) *Camera Mounting Subsystem*

The camera mounting subsystem encompasses hardware used to mount cameras on the pads, perimeter sites, and MLP's. The mounting equipment is used in various combinations to achieve the required fields of view with a minimum of vibration. The following hardware units are used in the camera mounting system:

Perimeter pedestals
Abutment pedestals
Pan-and-tilt mounts
Mobile tracker
MLP mounts
Wedges
Environmental housings and covers

(a) *Perimeter Pedestals*

Each perimeter site has four 6-inch-thick concrete pads which are flush with the road surface. Each pad will accommodate, and has provisions for bolt-stud mounting for four fixed pedestals of various heights (30 to 48 in.). The pedestals are welded aluminum structures with adapter plate welded on top. Each pedestal is grounded to a system ground cable. The adapter plates, welded to the site pedestals, are made from 1-inch-thick aluminum, coated with an electrically conductive and corrosion-resistant material. The adapter plate is drilled to accept wedges, pan-and-tilt mounts, environmental housings, or Hi-Hat Mitchell-type heads.

(b) *Abutment Pedestals*

Abutment pedestals are used for mounting long focal-length-lens cameras. Each perimeter site has four of these 24-inch high concrete structures.

(c) *Pan-and-Tilt Mounts*

Pan-and-tilt mounts provide a camera mounting surface that is adjustable in both azimuth and elevation. Pan-and-tilt mounts for LC-39 photo-optical use are mounted on adapter plates or wedge mounts. The maximum elevation angle adjustment without wedges is – 15 to + 60 degrees. The azimuth rotation is 360 degrees. Each pan-and-tilt mount has an 8-inch by 12-inch table which adapts to wedges, dovetail mounts, or camera explosion-proof housings. Both elevation and azimuth angle adjustments are secured with locking bolts provided with the pan-and-tilt mount.

(d) *Mobile Tracker*

A mobile Goertz tracker unit is positioned at each pad (A and B) at perimeter camera site 2 to support photo-optical launch operations requirements. Each mobile tracker unit is remotely controlled from a manually operated joy stick control console in LCC room 1P9. The mobile tracker units provide for tracking a launch vehicle from lift-off to the limit of the camera lens capability installed on the tracker. Visual tracking of the vehicle is through use of television boresight cameras. Control and monitoring of the television cameras is accommodated at the photo tracking consoles in LCC room 1P9.

A tracker control cabinet (TCC) and an operational television distributor are installed at both pads at perimeter site 2. The TCC distributor provides the control and timing required for the photo-optical cameras mounted on the mobile tracker. The operational television distributor provides the control and picture interface required between the mobile-tracker-mounted boresight television camera and the LCC room 1P9 camera controls or monitors.

Both mobile trackers can have up to five adjustable wedge mounts located between the photographic cameras and the special tracker platforms. These mounts provide a predetermined target orientation for each photo camera. Two heavy-duty clamps secure the boresight camera to a predetermined axis point. All mobile tracker photo-optical cameras are referenced to this axis.

(e) *Mobile Launcher Platform Mounts*

Cameras installed on the MLP zero or blast deck use environmental housings and covers mounted on adjustable mounts designed with a -10-degree elevation adjustment. Bases for these mounts are available in fixed 10-degree increments between 0 and 60 degrees. The elevation is predetermined within the 10 degrees of movement provided. After the desired elevation position is determined, the mount assembly is secured with bolts threaded into the base. The azimuth axis is determined and fixed prior to welding the base brackets to the MLP decks.

(f) *Environmental Housings and Covers*

Environmental housings are used over cameras in flame-impingement areas. Cameras in sustained flame areas are provided with an additional protective cover of stainless steel and ablative coating. The environmental housings are sealed and purged with gaseous nitrogen with provisions for gaseous nitrogen flow around the glass portion of the housings to cool the glass and to disperse water from the glass surface.

(6) *Gaseous Nitrogen Purge Subsystem*

The environmental camera housings used on the fixed service structure and the MLP incorporate a continuous gaseous nitrogen low-pressure purge of 50 psi during hazardous operations. During launch, a separate high-pressure, 750-psi gaseous nitrogen supply is used for window purge. A separate start signal is provided for the high-pressure gaseous nitrogen purge, which is sequenced with the camera start signal. This purge-start originates from an independent 28-V-dc power supply and associated relay panel located in PTCR room 207, rack 5337.

b. *Theory of Operation*

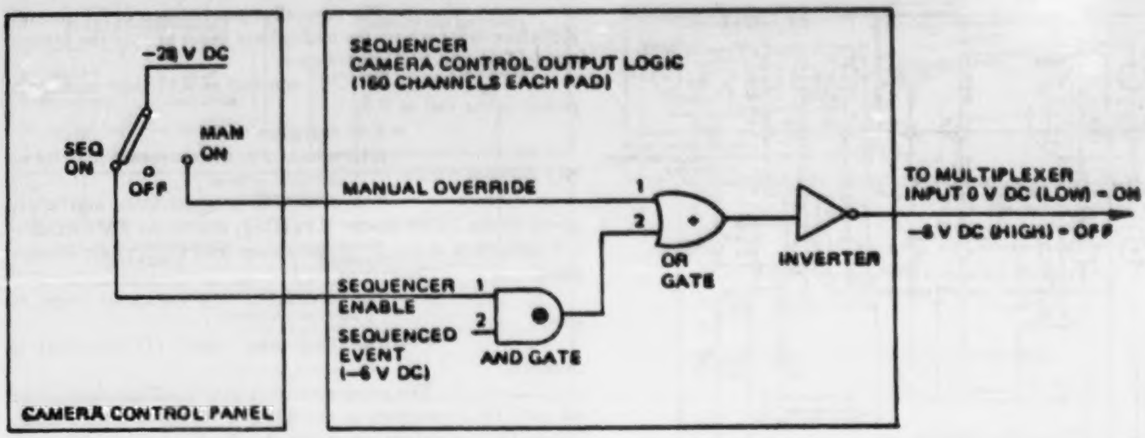
The following paragraphs explain the operation of the photo-optical control and status subsystem. The sequence is that which occurs with the initiation of a control signal (START) through the multiplexing, transmission, demultiplexing, and repeater stages to the actual camera start. The loop is completed by tracing the status signal from the CCR through the multiplexing, transmission, and demultiplexing stages to the display of status information on the camera control panels.

(1) *Initiation of Control Signals*

Control signals are those signals, which, after having been conditioned, ultimately turn on cameras. Control signals are generated in the camera control panels and in the ECC distributor by relay closures applying grounds to the multiplexer inputs. Camera control signals are referred to as camera start commands, or more simply, as "starts." The automatically sequenced control signals consist of -6-V-dc signals generated in the continuous and discontinue register output logic. These outputs are routed through the events patch panel to the camera control output gates. Reference the Astrodata manual for additional discussion of the sequencer operation.

There is an OR gate for each of the 160 camera channels. The OR gate will have a high output (near -6 V dc) which represents an ON input to the multiplexer (through an inverter) when either of the following conditions exist (see figure 146):

FIGURE 146



Camera Control Output Gating (Negative Logic).

–The switch on the camera control panel is in the MAN ON position and is supplying -28 V dc (manual override signal) to input 1 of the OR gate (high output).

–The switch on the camera control panel is in the SEQ ON position supplying -28 V dc (sequencer enable signal) to input 1 of the AND gate, and -6 V dc from the events register output logic is present at input 2 of the AND gate simultaneously (high output). If either of these signals is not present, the output of the AND gate will be low and the input to the multiplexer will be OFF.

(a) *Automatic Control*

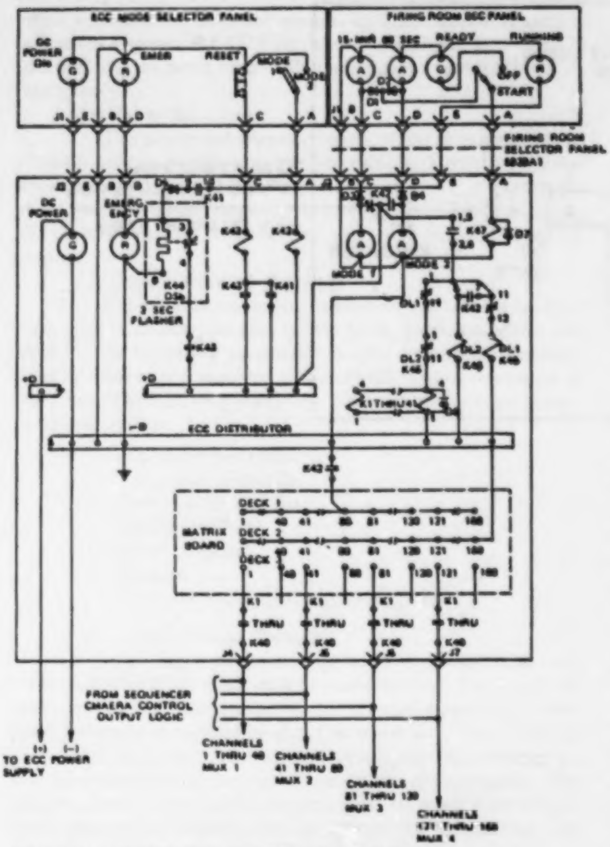
Automatic, or sequencer, control is initiated when the sequencer up/down counter reaches the count which has been preset into the START TIME thumbwheel switches of the continuous or discontinuous programmers. Each programmer contains 50 five-section thumbwheel switches. Twenty-five of these switches in the continuous events programmer are used to preselect the start times of up to 25 events (camera starts) which will not be interrupted during a hold. The other 25 switches preselect the stop times for the same events. The discontinuous events programmer switches serve the same purpose, but these events will turn off during a hold and turn on again when the count proceeds.

Each switch has five sections. From left to right, the sections will select: (a) + for countup or – for countdown, (b) hundreds, (c) tens, (d) units, and (e) tenths of seconds. When the sequencer up/down counter reaches the time which has been preset into the START TIME switches, the output of the switch will be 0 V dc, or ground. This output will enable the logical set enable input of a 100 kHz common clock flip-flop in the event output logic, and the flip- flop will set on the next positive-going pulse from the sequencer clock pulser. When the flip-flop sets, its output will go to 0 V dc. The flip-flop output is inverted in the events register, causing -6 V dc to be routed (through the events patch panel) to the AND gate input 2 of the output control logic shown in figure 146. The STOP TIME thumbwheel switches of the programmers operate in the same manner except that their output is applied to the logical reset enable input of the flip-flop causing the flip-flop to reset on the next positive-going pulse from the clock pulser. The action is then reversed, and the events register output for the event is low (0 V dc) at the AND gate. The AND gate (figure 146) can have a high output only when both the -6 V dc (sequenced event signal) and the -28 V dc (sequencer enable signal) are present simultaneously. The sequenced event term is generated as described previously, and the sequencer enable term is generated by placing the switch on the camera control panel in the SEQUENCE ON position.

(b) *Manual Override Control*

Manual control of a camera channel is initiated by placing the switch on the camera control panel in the MANUAL ON position. In this case, -28 V dc is applied to input 1 of the OR gate (figure 146), and the sequencer enable signal is no longer present at the AND gate input 1. The AND gate output is now low and the B camera control panel is controlling

FIGURE 147



Emergency Control Operation Simplified Schematic

the camera channel, regardless of whether or not the sequenced event term (-6 V dc) is present at the AND gate input 2; therefore, the manual control at the camera control panels overrides the sequencer control as stated in b.(1)(a).

(c) *Emergency Camera Control*

Emergency camera control overrides both manual and sequencer control. Equipment involved includes the ECC mode selector panel, the panel, the ECC panels in firing rooms 1 and 3, the ECC distributor, and the ECC power supply. The emergency control signals are generated in the ECC distributor and applied to the multiplexer inputs by means of a tap or "Y" arrangement in the cables between the sequencer and multiplexer. When the ECC system is activated, a ground (0 V dc) is placed on each channel which has been designated as emergency, thus turning the channel on, regardless of any other control signal on the line.

Mode I Operation Assume that the ECC distributor has been programmed as desired, and that the ECC system is to be operated in mode I (15 minute run time). The ECC power supply is turned on and the MODE I/MODE II switch on the ECC mode selector panel is in the MODE I position (the DC POWER and MODE I indicators will light on the ECC distributor). When the start switch on the FR ECC panel is closed, + 24 V dc power is applied to the coil of K47, to the coils of relays K1 through K41 through the normally closed (NC) contacts of time delay relays DL1 and DL2, and also to the coil of DL1 through the normally cosed (NC) contacts of K42 (see figure 147). Relays K1 through K41 energize and the following events occur simultaneously.

– The normally open contacts of K1 through K40 close and connect the multiplexer input lines to the ground bus (-D) in the ECC distributor.

– The NO contacts of K41 close and apply power to the coil of K43.

– K43 energizes.

– K43 is locked in the energized state by its NO contacts.

– The K43 NO contacts close and apply power to the 2 PPS flasher K44 (DS5) and to the EMERGENCY indicators in the ECC distributor and ECC mode selector panel.

– The EMERGENCY indicators begin to flash.

– The DL1 time delay (15 minutes) is initiated.

The programmed channels will continue to be on until DL1 energizes or the START switch is turned OFF. When DL1 energizes, its normally closed contacts open and remove power from K1 through K41 and the above action is reversed except that K43 remains energized and the EMERGENCY indicators continue to flash. The EMERGENCY indicators can be extinguished only by pressing the RESET momentary pushbutton switch on the ECC mode selector panel or by turning off the ECC power supply to remove power from the coil of K43. When K43 deenergizes, its NO contacts open, and releasing the RESET switch cannot apply power to the coil.

Mode II Operation For mode II operation, the MODE I/MODE II switch on the ECC mode selector panel is placed in the MODE II position. This setting will apply a ground to the coil of K42 (see figure 147) and cause it to energize. The K42 NO contacts will close, lighting the MODE II indicators, and the NC contacts will open, extinguishing the MODE I indicators and connecting deck no. 1 of the matrix board to ground. It should be noted that any channels that are programmed for mode I will also operate in mode II because deck 2 is tied directly to the ground bus.

(2) *Programming*

Before the timing and control subsystem can transmit control signals, programming must be accomplished. Equipment to be programmed is the continuous and discontinuous events programmers and the various patch panels. The following paragraphs explain the operation of these devices.

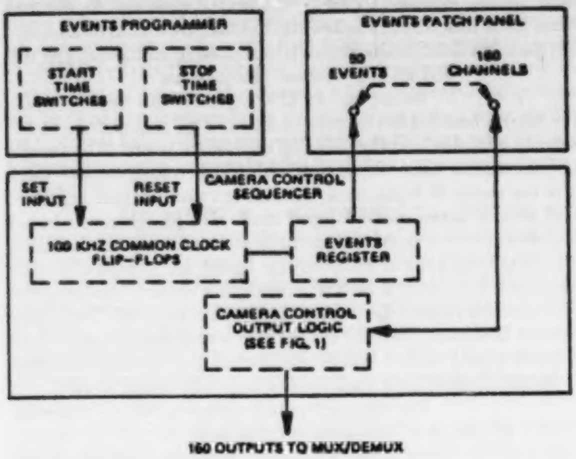
(a) *Control Switch Patch Panel*

The control switch patch panel provides a means of selecting the channel that a given camera control switch can control. Figure 148 illustrates how this is accomplished.

The patch panel (AMP 1632) contains 1632 jacks arranged in 48 vertical columns and 34 horizontal rows. For purposes of this discussion, the jacks will be referred to by their schematic (63E910179) callout, consisting of a letter representing the column and a number representing the row. For example, the fifth jack in the tenth row is referred to as E10. Actual callouts on the panel are as shown in the pictorial view of figure 148. The large blocks at the top of the panel are connected to the sequencer camera control output logic. The number in each block represents the multiplexer channel to which it is connected. The two jacks on the left (wired in parallel) are connected to input 1 of the camera control output logic OR gate. The two center jacks supply the sequencer enable voltage to input 1 of the AND gate and the jacks on the left are the status output from the status demultiplexer.

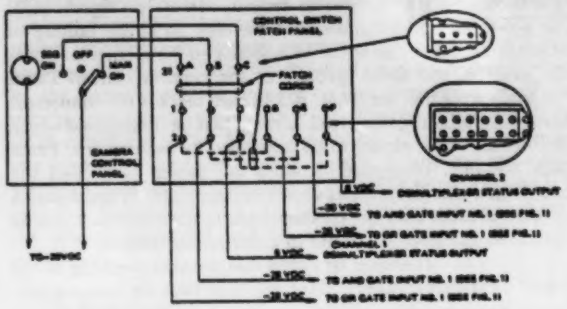
The group of small blocks (beginning with row 21) on the patch panel access the camera control panel switches. The number in each block represents the control switch to which the jacks are connected. The jack on the left in each block is con-

FIGURE 149


EVENTS PROGRAMMER
START TIME SWITCHES
STOP TIME SWITCHES
EVENTS PATCH PANEL
50 EVENTS
160 CHANNELS
CAMERA CONTROL SEQUENCER
SET INPUT
RESET INPUT
100 KHZ COMMON CLOCK FLIP-FLOPS
EVENTS REGISTER
CAMERA CONTROL OUTPUT LOGIC (SEE FIG. 1)
160 OUTPUTS TO MUX/DEMUX

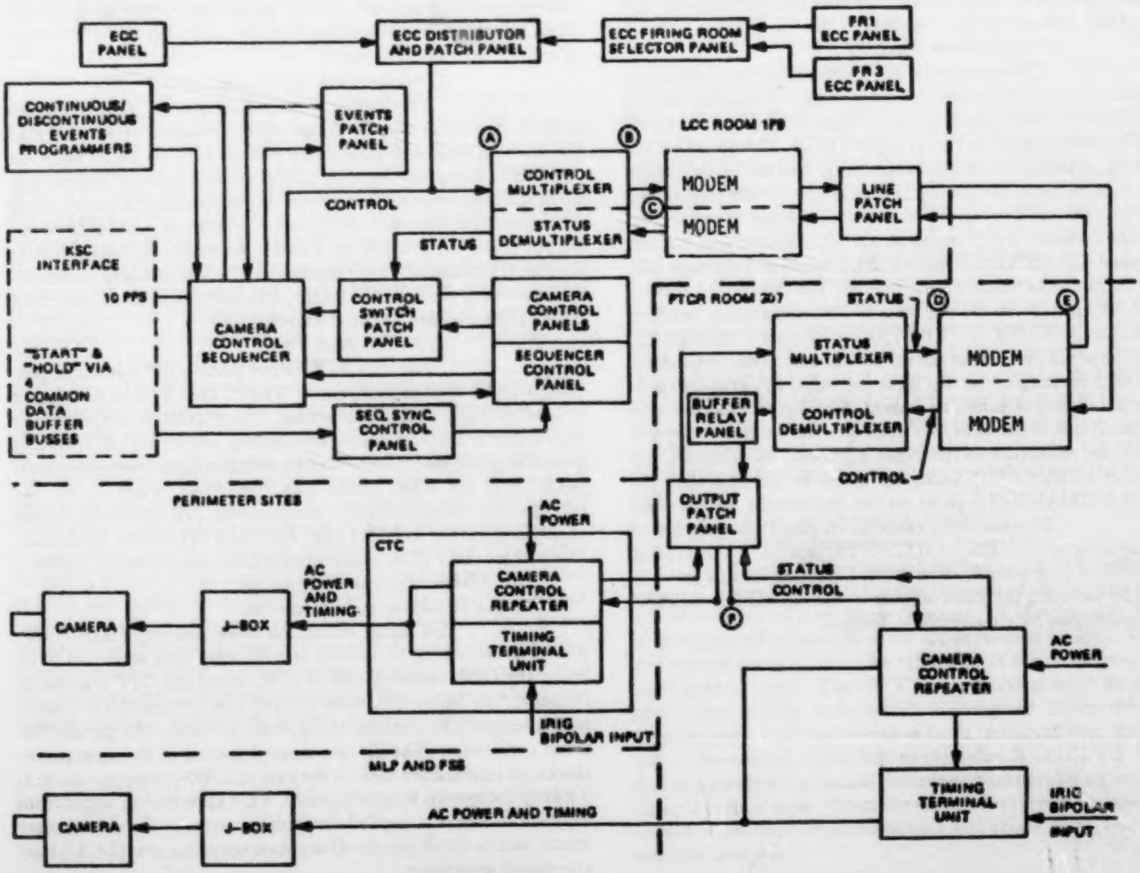
Events Patching Signal Flow Diagram.

FIGURE 148


CONTROL SWITCH PATCH PANEL
SEQ ON
OFF
MAN ON
21
A
B
C
PATCH CORDS
1
2
CAMERA CONTROL PANEL
CHANNEL 2
5 VDC
DEMULTIPLEXER STATUS OUTPUT
-28 VDC
TO AND GATE INPUT NO. 1 (SEE FIG. 1)
-28 VDC
TO OR GATE INPUT NO. 1 (SEE FIG. 1)
CHANNEL 1
5 VDC
DEMULTIPLEXER STATUS OUTPUT
-28 VDC
TO AND GATE INPUT NO. 1 (SEE FIG. 1)
-28 VDC
TO OR GATE INPUT NO. 1 (SEE FIG. 1)
TO -28VDC

Control Switch Patch Panel Simplified Schematic

FIGURE 150


ECC PANEL
ECC DISTRIBUTOR AND PATCH PANEL
ECC FIRING ROOM SELECTOR PANEL
FR1 ECC PANEL
FR3 ECC PANEL
CONTINUOUS/ DISCONTINUOUS EVENTS PROGRAMMERS
EVENTS PATCH PANEL
A
B
LCC ROOM 1P9
CONTROL MULTIPLEXER
STATUS DEMULTIPLEXER
C
MODEM
MODEM
LINE PATCH PANEL
CONTROL
STATUS
KSC INTERFACE
10 PPS
"START" & "HOLD" VIA 4 COMMON DATA BUFFER BUSSES
CAMERA CONTROL SEQUENCER
CONTROL SWITCH PATCH PANEL
CAMERA CONTROL PANELS
SEQUENCER CONTROL PANEL
SEQ. SYNC. CONTROL PANEL
PTCR ROOM 207
STATUS
D
E
STATUS MULTIPLEXER
CONTROL DEMULTIPLEXER
MODEM
MODEM
BUFFER RELAY PANEL
CONTROL
PERIMETER SITES
OUTPUT PATCH PANEL
AC POWER
CTC
AC POWER AND TIMING
CAMERA CONTROL REPEATER
TIMING TERMINAL UNIT
STATUS
CONTROL
F
CAMERA
J-BOX
IRIG BIPOLAR INPUT
CAMERA CONTROL REPEATER
AC POWER
TIMING TERMINAL UNIT
IRIG BIPOLAR INPUT
MLP AND FSS
CAMERA
J-BOX
AC POWER AND TIMING

Camera Control and Status Subsystem Functional Diagram.

nected to the manual control terminal and the center jack is connected to the sequencer terminal of the switch. The jack on the right is connected to the switch indicator lamp (see figure 147). The group of blocks numbered 1 through 16 at the bottom of the panel are connected to the 16 switches on the momentary control panel in the same manner as the camera control Panel switches, except that the center jack in each block is not connected. When programming this panel, it must first be determined which mux/demux channels are to be controlled by each switch. Patch cords are then connected between the switch jacks and the mux/demux channel jacks as shown in figure 148. When a switch is to control more than one channel, patches from one mux/demux channel to the next are made in daisy-chain fashion.

It should be noted that parallel patching at the control switch patch panel is not desirable because it could produce an erroneous status indication at the camera control panels. If two camera channels were patched to the same control switch and one of the channels malfunctioned in the CCR, then the camera control panel indicator would still light if the other channel functioned properly. For this reason, any parallel usage of camera channels should be done on the events patch panel.

(b) *Events Programmers*

Both the continuous and discontinuous events programmers are operated identically; therefore, only the continuous events programmer will be discussed. The continuous events are numbered 1 through 25 and the discontinuous events are numbered 26 through 50. Each event has a START TIME thumbwheel switch. The countdown time which the event is to start and stop is set into the appropriate switch by turning the five thumbwheels on each switch until the desired numeral appears in the window of each section.

(c) *Events Patch Panel*

The outputs of the switches on the continuous and discontinuous programmers are patched to camera control output logic at the events patch panel. Figure 149 shows the signal flow. The patch panel has two groups of jacks. The group on the left is used to patch the continuous events, and the group on the right is used to patch the discontinuous events. In the continuous events side, the jacks are grouped in pairs enclosed in rectangles. The large sections of rectangles at the top, center, and bottom of the panel (CAMERA CHANNELS), numbered 1 through 160, are the output jacks which are routed over 160 lines to the camera control output logic in the sequencer. The two smaller sections of rectangles (EVENT OUTPUTS), numbered 1 through 25, contain the input jacks from the events register in the sequencer. Within each rectangle, the two jacks are wired in parallel to provide for paralleling channels as desired. The discontinuous events (right-hand) side of the panel is identical to the continuous events side with the exception of the event numbers. In addition, the CAMERA CHANNELS jacks are wired in parallel with the CAMERA CHANNELS jacks on the continuous events side.

Programming of the patch panel is accomplished by connecting an EVENT OUTPUTS jack to a CAMERA CHANNELS jack with a patch cord. Channels can be used in parallel by patching the pairs of jacks in the CAMERA CHANNELS rectangles in a daisy-chain fashion.

NOTE

Event 25 is used to activate the pad sequencer hold inhibit circuit (EVENT 25) and is patched to the unnumbered jack directly below the CAMERA CHANNELS no. 151 jack. the hold inhibit circuit is described in paragraph 1.b(10).

(d) *ECC Distributor Matrix Board*

Before the ECC equipment can be employed, the matrix board must be programmed. This step is done by inserting skip pins into the holes on the matrix board. The matrix board contains three decks, each with 160 terminals (holes). Deck 1 is the mode II input deck with all terminals bused together, and deck 2 is the mode I input deck with all terminals bused together. Deck 3 is the output deck with all terminals isolated. The skip pins used to program the board are designed to connect deck 1 or deck 2 with a terminal on deck 3. To program the board for mode I operation, mode I pins are used. These pins contain insulating material at the point where they intersect deck 1, so that only deck 1 will be connected to a terminal on deck 3. Mode II pins have insulation which will isolate deck 2.

The matrix board is programmed by inserting mode I (black) pins into holes for channels selected for mode I operation, and mode II (white) pins into holes for channels selected for mode II operation.

(e) *Mode Selection and Operation*

The mode of operation for emergency control is determined at the ECC mode selector panel by setting the MODE I/MODE II switch to either MODE I or MODE II. With the switch in the MODE I position, the emergency cameras will run for 15 minutes, with the switch in MODE II position, the emergency cameras will run for 60 seconds. The cameras are turned on by closing the START/OFF switch on the ECC panel in one of the firing rooms.

(f) *Modem Line Patch Panel*

The line patch panel contains 64 jacks which are used to patch the output signals from system 1 or system 2 to the data modem at PTCR-A or PTCR-B. This panel must be patched to complete the loop for the control system. Patching is accomplished by connecting two-conductor shielded patch cords from the input system 1 or system 2 sequencer jackfields to the output [PAD A, PAD B, or Vehicle Assembly Building (VAB) interface] jackfields. These patches can be made in any combination provided that CONTROL jacks are patched together and STATUS jacks are patched together.

(g) *PTCR Patch Panels*

The PTCR-B output patch panel has status provisions and is used to patch starts. The PTCR-A patch distributor is used to patch starts and status. The PTCR-A output patch distributor is a 42-connector unshielded patch rack (5331A7). It is used to patch multiplexer starts and status to the perimeter sites, MLP, and the FSS. [Reference 79K07360, sheet 7, for the multiplexer channel circuit assignments (160-channel system capability) for the LC-39A pad, FSS, and MLP sites. Reference sheet 12 for the PTCR photo-optical cable interconnect system.]

(3) *Multiplexing and Transmission*

(a) *Parallel-to-Serial Conversion*

The signal which has been processed and conditioned as described previously is a dc level shift signal, 0 V dc being the ON condition and -6 V dc being the OFF condition. At point A in figure 150, there are 160 lines (channels) of control multiplexers. The control multiplexer performs the parallel-to-serial conversion. The bit rate control section of the multiplexer clocks the multiplexer logic at the rate of 2,000-pulses-per-second. To keep the system in synchronism, a 2.4 kpps timing signal from the data modems is applied through inverters to the clock pulser inputs and to the divide-by-48 decimal counting unit (DCU) load command generator.

The divide-by-48 DCU load command generator counts continuously during multiplexer operation. When the

DCU reaches the count of 48, it resets to zero, generates a load command, and applies the load command to the multiplexer shift register, which then directly resets the 48-bit shift register flip-flops. After the shift register flip-flops have been reset, they are loaded simultaneously with the 7-bit frame reference word (1101010 or 0010101), 1-bit of loop check information, and 40 bits of camera control information. All 48 shift register flip-flops are clocked simultaneously by the shift clock pulses from the bit rate control logic. When the shift clock pulse goes positive, the information stored in each flip-flop is shifted out and into the succeeding flip-flop.

This procedure is accomplished by gating the true output of one flip-flop into the false input of the succeeding flip-flop, and the false output of the second flip-flop into the true input of the third, etc. Finally, the information is shifted out of the register as binary ones and zeros represented by 0-V-dc and -6-V-dc levels, respectively. At this point, the control information is still in dc level shift form which is applied to the multiplexer output logic. The multiplexer output logic converts the dc level shift information into an RZ serial data train of ones and zeros represented by voltage levels of + 5 V dc and − 5 V dc, respectively, as shown in figure 151. The RZ serial data train is then filtered to 0 square off the pulse and eliminate transients.

(b) *Demultiplexer*

The control demultiplexers located at the PTCR's receive the outputs of the data modems and demultiplex them into parallel outputs (40 for each demultiplexer) which are used to drive relays in the camera control repeaters.

The serial pulse train from the data modems enters the demultiplexer control logic section which consists of zero and one threshold detectors, clock pulsers, load data flip-flops and associated gates, frame reference load command flip-flops, and activity sensors.

The threshold detector clock pulser logic consists of two Schmitt trigger threshold detectors, a two-way OR gate, a clock pulser, and three inverters. The positive-going serial data train from the data modems are converted into negative-going (0 to -6 V) pulses by the one threshold detector; at the same time, the negative-going pulses are converted to pulses of 0 to -6 V by the zero threshold detector. (The Schmitt trigger circuits square the pulses and increase their amplitude.) The threshold detector outputs are inverted and fed to the 56-bit shift register. The threshold detector outputs are fed to a two-way OR gate which generates clock pulses which clock the load data flip-flops.

(c) *Frame Reference Comparator*

The frame reference comparator samples the 56-bit shift register and extracts the frame reference information. If the comparator sees the frame reference word, 1101010, followed by 41 bits of camera control and loop check information, and then the complement of the frame reference work, 0010101, a load command will be generated and the loop check and camera control bits will be shifted out and stored in the 41-bit storage register. At the same time, the 56-bit shift register is primed for another sampling by the comparator. The trailing frame reference word in each case is also the leading frame reference word for the next frame. If the frame reference comparator does not detect a frame reference word which is always the complement of the preceding frame reference word, no load command will be generated and the demultiplexer will have no output. This ensures a high immunity to noise and a high degree of system security.

(d) *Data Outputs*

Once the frame reference has been verified and a load command has been generated by the frame reference comparator, the loop check bit and 40 bits of camera control information are shifted into the 41-bit storage register. The storage register outputs operate relay drivers which supply a ground to the relays in the camera control repeaters. The negative side of the mux/demux power supply (-28 V dc) is wired to one side of the CCR relays in parallel. When a given relay driver sees a binary one input from the 41-bit storage register, it saturates and causes a ground (0 V dc) to be applied to the CCR relay, causing it to energize. Conversely, if a zero is stored in the storage register, the relay in the CCR will see a high resistance and will not energize.

The signal has now been converted to parallel data by the demultiplexer so that the signal to point F in figure 150 is 40 lines of dc level shift information.

(4) *Loop Check Operation*

The loop check circuit provides a method of verifying that the mux/demux loop is in synchronism and transmitting information.

The control switch patch panel provides five pushbutton indicating switches (one for each mux/demux loop), which are used to activate the loop check circuit. When one of these switches is pressed, the eighth bite in the serial data train will be a binary one which will cause the appropriate flip-flop in the multiplexer shift register to have a true output. This output is connected to one input of an AND gate, the other input of which is the load command pulse. When both inputs are true, the AND gate will have an output and a binary one will be stored in the storage register to be transmitted through the loop to the demultiplexer; the loop check bit is ANDed with the -28 V dc from the demux/mux power supply; and, if both inputs are true, the demultiplexer output for the eighth bit will be an ON signal which is transmitted directly to the status multiplexer and finally back to the LCC demultiplexer. Here it is demultiplexer along with the 40 bits of status information and used to light the LOOP CHECK indicator on the control switch patch panel. If a LOOP CHECK lamp does not light when the switch is pressed, the associated mux/demux loop is not transmitting properly.

(5) *Synchronization Detection and Indication*

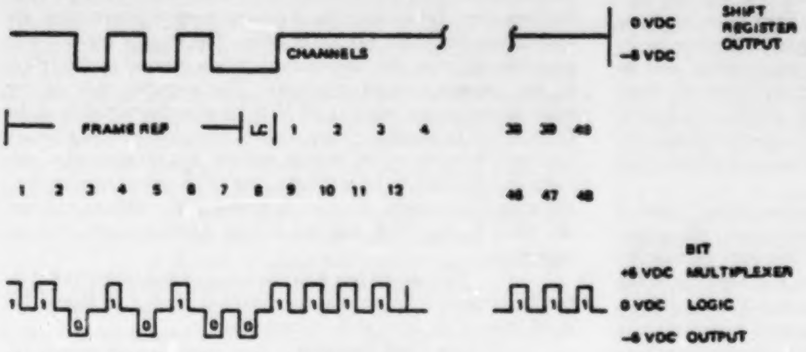
Each mux/demux and demux/mux unit has a SYNC indicator located on its front panel which serves to verify that the demultiplexer is in synchronism with its associated multiplexer. This is accomplished when the 2.4 kpps shift clock pulse in the demultiplexer bit rate control logic is sampled by an activity sensor for approximately the first 700 microseconds of each pulse, and the output of the load command generator is sampled by another activity sensor, for approximately 25 ms. When both of these outputs are true, a lamp driver is enabled and the indicator will light.

(6) *Timing and Repeating Equipment*

(a) *CCR Operation*

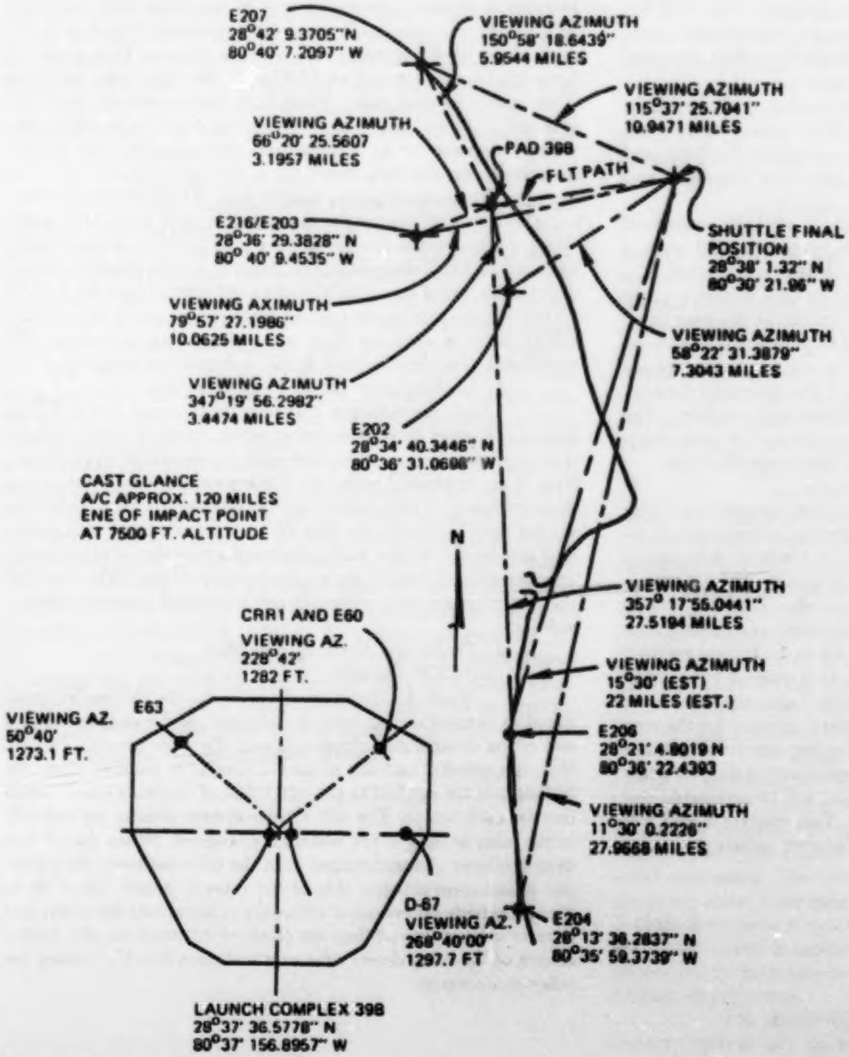
Each CCR channel receives, via the buffer relay panel, a control signal from the channel of the output logic of one of the control demultiplexers and -28 V dc power. The -28 V dc is applied to one side of the CCR relay in parallel. The control signals are applied to the other side of the relay (one control line for each relay). The -28 V dc is always present on one side of the relay as long as the system is energized. When the control demultiplexer channel output is in the off condition, the potential at the control input side of the relay is nearly -28 V dc so that essentially no potential difference exists across the relay, and current cannot flow. When the channel is turned on, the output circuit of the relay driver saturates and goes to 0 V, causing the relay to energize.

FIGURE 151


CHANNELS
0 VDC
–6 VDC
SHIFT
REGISTER
OUTPUT
FRAME REF
LC
1 2 3 4
38 39 40
1 2 3 4 5 6 7 8 9 10 11 12
46 47 48
1 1 0 1 0 1 0 0 1 1 1 1
1 1 1
+6 VDC
0 VDC
–6 VDC
BIT
MULTIPLEXER
LOGIC
OUTPUT

Multiplexer Shift Register and Logic Outputs.

FIGURE 152


E207
28°42' 9.3705" N
80°40' 7.2097" W
VIEWING AZIMUTH
150°58' 18.6439"
5.9544 MILES
VIEWING AZIMUTH
115°37' 25.7041"
10.9471 MILES
VIEWING AZIMUTH
66°20' 25.5607
3.1957 MILES
PAD 39B
FLT PATH
E216/E203
28°36' 29.3828" N
80° 40' 9.4535" W
SHUTTLE FINAL
POSITION
28°38' 1.32" N
80°30' 21.96" W
VIEWING AXIMUTH
79°57' 27.1986"
10.0625 MILES
VIEWING AZIMUTH
58°22' 31.3879"
7.3043 MILES
VIEWING AZIMUTH
347°19' 56.2982"
3.4474 MILES
E202
28°34' 40.3446" N
80°36' 31.0698" W
CAST GLANCE
A/C APPROX. 120 MILES
ENE OF IMPACT POINT
AT 7500 FT. ALTITUDE
N
VIEWING AZIMUTH
357° 17'56.0441"
27.5194 MILES
CRR1 AND E60
VIEWING AZ.
228°42'
1282 FT.
VIEWING AZIMUTH
15°30' (EST)
22 MILES (EST.)
VIEWING AZ.
50°40'
1273.1 FT.
E63
E206
28°21' 4.8019 N
80°36' 22.4393
VIEWING AZIMUTH
11°30' 0.2226"
27.9668 MILES
D-67
VIEWING AZ.
268°40'00"
1297.7 FT
E204
28°13' 38.2837" N
80°35' 59.3739" W
LAUNCH COMPLEX 39B
28°37' 36.5778" N
80°37' 156.8957" W

Camera Locations and Look Angles.

When the relay energizes, 120 V ac power is routed through the relay contacts through the camera service cable to the camera motor and the camera runs. At the same time, an enable signal (ground) is routed to the corresponding channel of the associated TTU. This enable signal causes the TTU LED driver to supply the selected timing code to the same camera.

(b) *TTU Operation*

The TTU receives IRIG-differentiated bipolar timing codes from the KSC timing system through the timing distributor and monitor panel and converts it to a dc level shift signal of sufficient amplitude to drive the timing LED in motion picture cameras. Each TTU operates in conjunction with one single-phase CCR or two three-phase CCR's supplying control and timing signals to 10 motion picture cameras. Each TTU channel is enabled by one CCR channel and the two companion channels are routed over the same cable to a single camera.

(c) *Time Code Reconstruction*

The TTU contains a bipolar level shift converter which accepts IRIG bipolar signals with a minimum amplitude of 2 V base-to-peak. At present, the time codes used are IRIG-A, IRIG-B, IRIG-E, and IRIG-H. The bipolar signals are applied to Schmitt trigger circuits which produce dc level shift pulse trains (0 to -6 V dc) which follow (track) the input pulses. The outputs of the bipolar level shift converter are applied to AND gates on LED driver cards (one for each channel). The other input to these AND gates is the enable signal from the CCR. When the two signals appear at the AND gate simultaneously, the AND gate is turned on and the LED in the camera glows. When the bipolar level shift converter output is at 0 V and the AND gate is turned off, the camera timing LED turns off. LED currents may be monitored at the LED monitor chassis on the TTU.

(7) *Status Signals*

(a) *Generation of Status Signals*

The CCR's are capable of generating status signals to be multiplexed and transmitted back to the LCC demultiplexers where they can be demultiplexed and routed to status lamps on the camera control panels. The equipment is designed to sense the presence of 120 V ac on the camera START relay contacts that supply voltage to the camera motor. This status multiplexer input results in an illumination of a "lighted" switch handle on the camera control panel (reference 79K07360, sheet 3).

(b) *Master Status Switch*

There are two master status switches, one for each photo-optical system. The master status switch, when in the TEST (up) position, will illuminate the channel selector switches which are patched to their respective multiplexers. Normal status is indicated with the switch in the down position.

(8) *Backpatching the LCC mux/demux*

The LCC mux/demux can be backpatched to check the operation of the LCC portion of the control and timing subsystem. Backpatching consists of disconnecting the cables from J101 and J102 of each mux/demux, and then connecting J101 to J102 with a short piece of coaxial cable. The result is that the control multiplexer output is fed directly to the status demultiplexer input and the loop is closed. In this configuration, each camera control channel which is turned on (either automatically or manually) will produce a control multiplexer output. Since the control multiplexer is patched directly to the status demultiplexer input, the status demultiplexer will produce an output which will cause the corresponding status lamp in the switch handle on the camera control panel to light.

(9) *Camera Control Sequencer*

Start, hold, and hold-inhibit signals can be provided to operate the camera control sequencer locally from LCC room 1P9. The sequencer is normally preset to a preselected count before beginning a sequence. When this count occurs, the launch sequence start switch is closed, starting the sequence counter. If, while the counter is running, a hold signal (closure) is received, the counter stops. During a launch countdown, the launch processing system will provide the start and stop signals, but not hold inhibit.

(10) *Hold Inhibit*

The camera control sequencer has hold-inhibit circuits which are used to inhibit any hold signals from LPS during critical intervals of the countdown. If a hold were allowed to stop the sequencer at certain times, film breakage and camera damage could result when certain cameras are stopped and restarted (discontinuous events cameras). Also, a hold of too long a duration could cause film runout (on continuous events cameras) and possible damage to camera motors. Sequencer circuitry permits a hold inhibit to be generated automatically by the sequencer. However, it is planned that the hold inhibit signal be generated internally by the camera control sequencer at a preprogrammed time. When the hold inhibit signal is present, the counter will continue to run in the presence of a hold command. When a hold-inhibit term is generated, its associated lamp driver will supply a ground to the appropriate indicator on the sequencer front panel. With the term not present, the lamp will extinguish.

c. *Other Equipment*

(1) *Sequencer Synchronization Control Panel*

System 1 and system 2 can be operated independently or simultaneously. The sequencer control panel provides a switching arrangement whereby the launch start and hold signals can be switched from any of four common data buses to either sequencer. Simultaneous synchronized operation is accomplished by setting both switches (system 1 and system 2 sequencers) to operate from the same common data buffer bus.

(2) *ECC FR Selector Panel*

The ECC firing room selector panel enables the ECC subsystem of system 1 or system 2 to be operated from either of the two firing rooms.

(3) *Sequencer Power Supply Monitor Panel*

The sequencer power supply monitor panel in rack E14 is provided to monitor the voltage outputs of the dual power supply in the pad A sequencer.

d. *Operation and Maintenance*

For further information on the operation and maintenance of this system, refer to Operation and Maintenance and Specifications Document 79K14913.

e. *Shuttle Photographic Tracking Coverage*

Photographic coverage of the Shuttle launch vehicle has been implemented per requirements in the Program Requirements Document (PRD) and supported per the Photographic Acquisition-Disposition Document (PA-DD) by the photographic contractor.

Coverage is provided from prior to ignition until after SRB separation or until limit of visibility. Location of various cameras discussed in this subsection are shown in figure 152.

This sequence of coverage starts with a remote-controlled tracking mount on the east side of the launch complex that provides three 16mm overlapping views of the vehicle from T minus 12 seconds through lift-off and a committed altitude of 1200 feet. This mount, under normal conditions, usually tracks well beyond the commitment and is controlled from the Launch Control Center.

Also, at ignition, cameras are started at three off-complex intermediate focal length optical tracker tracking mounts. These mounts are located at universal camera sites that are north, west, and south of the launch pad at a distance of 3 to 7 miles. Each of these mounts has a 16mm and a 70mm camera for coverage of early flight. Although they do provide coverage at lift-off, the lenses are not in proper focus and are not committed until the vehicle has reached an altitude of approximately 1200 feet. These cameras provide coverage until augmented by long-range instruments. One mount, in addition to the above three mounts, is normally located within 3 miles southeast of the pad. This mount provides 70mm coverage of lift-off through rollover. This mount is primarily a platform for a broadcast-release television camera.

The long-range tracking instruments (mounts) are either mobile trailers or stationary units. They are manual or computer-assisted and are linked to the Eastern test range radar and range computer.

They are identified by type of mount:

MIGOR – Mobile intercept ground optical recorder
It ground optical recorder
ROTI – Recording optical tracking instrument

These instruments utilize 35mm or 70mm cameras coupled to lenses with focal lengths ranging from 100 inches to 500 inches. These lenses are auto-focus and temperature compensated.

Coverage by these instruments is from first acquisition until LOV. Two mounts are located north and two mounts are located south of the flight line at a distance of 6 to 40 miles. Two of these mounts (one north and one south) are planned to track the Orbiter through and after SRB separation. The other two mounts will follow the launch vehicle until SRB separation and then track SRB entry to LOV.

All of the above cameras, mounts, and instruments are dedicated to requirements of viewing structural integrity, propulsion performance, and possible flight anomalies of the launch vehicle. These data are committed only during daylight hours (sunrise plus 45 minutes, sunset minus 45 minutes).

In the event of a launch being scheduled beyond this daylight period, exposure will be adjusted to "flame exposure" providing coverage of the plumes.

In addition, all tracking coverage is contingent upon weather conditions and cloud coverage at time of launch.

REPORT CHANGE LOG
PHOTO AND TV SUPPORT TEAM REPORT

as of 5/7/86

CHANGE NOTICE NO.	CHANGE NOTICE DATE	PAGES AFFECTED	ITEMS AFFECTED
1	5/7/86	ii	Correct page numbers
1	5/7/86	1	Remove probable from cause
1	5/7/86	41	Define correct number of CAD systems used
1	5/7/86	53	Change event time to 110.250
1	5/7/86	101	Rewrite last paragraph for clarity
1	5/7/86	110	Rotate photo 90° CCW for correct orientation
1	5/7/86	111	Rotate photo 90° CCW for correct orientation
1	5/7/86	184	Define actual exposure time of photograph
1	5/7/86	185	Change event time
1	5/7/86	186	Change event time and rotate photo 180° for proper orientation
1	5/7/86	187	Change event time
1	5/7/86	188	Change orientation of photograph
1	5/7/86	212	Change orientation of photograph
1	5/7/86	214	Change orientation of photograph
1	5/7/86	237	Define causes of camera failures
1	5/7/86	249	Change orientation of photograph
1	5/7/86	291	Define failure point; define fluid from laboratory analysis, define evidence that exists; and further discuss camera failures.

REPORT CHANGE LOG
PHOTO AND TV SUPPORT TEAM REPORT

as of 5/7/86

CHANGE NOTICE NO.	CHANGE NOTICE DATE	PAGES AFFECTED	ITEMS AFFECTED
1	5/7/86	1, 2, 3, 12, 13, 14, 15, 16, 17, 26, 27, 31, 33, 34, 35, 44, 47, 55, 56, 57, 59, 61 65, 73, 81, 83, 85, 87, 89, 91, 93, 95, 97, 99, 103, 107, 109, 113, 115, 116, 119, 121, 123, 125, 127, 129, 131, 133, 135, 137, 139, 141, 143, 145, 146, 148, 149, 151, 152, 154, 155, 157, 159, 161, 163, 165, 167, 169, 171, 173, 175, 176, 178, 180, 182, 189, 190, and 194	Make minor editorial and typographical corrections
1	5/7/86	200 through 298	Change page numbers and make minor editorial and typographical corrections
1	5/7/86	270, 271, 276, 277, 278, 280, 281, 282	Renumber tables
1	5/7/86	A-2, A-6, A-7, A-8, A-9, A-10, A-14, A-15, A-20, A-21, A-24, A-29, A-36, A-40, A-41 and A-43.	Make minor editorial and typographical corrections

Appendix O—NASA Search, Recovery and Reconstruction Task Force Team Report

Search, Recovery and Reconstruction Task Force Team Report of The Challenger Mishap

Date of Mishap: January 28, 1986

Edward A. O'Connor, Jr.
Colonel, USAF
Team Lead

MAY 14, 1986
CHANGE NOTICE #2

"NOTICE"

This document may be exempt from public disclosure under the Freedom of Information Act. Request for its release to persons outside the United States Government should be handled under the policy of NMI 1382.3A, "Release of Accident Investigation Reports to the Public."

PRELIMINARY

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NOTES:

Volume 2 of the SRR report dated April 1986 is now broken into three volumes (Vol. 2, 3, and 4).

Enclosure 9 is added as a part of Volume 4.

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I. Introduction

At 11:38:00.010 Eastern Standard Time (EST) on January 28, 1986, Mission 51-L Shuttle was launched from Launch Complex (LC) 39B at the John F. Kennedy Space Center, Florida, with seven astronauts aboard. As observed and recorded on video tape at 74.130 seconds after liftoff, the Shuttle was engulfed in flames. It began a catastrophic breakup. Both Solid Rocket Boosters (SRB's) separated from the External Tank (ET) and continued powered flight on erratic courses until the Range Command Destruct signal was sent by the Range Safety Officer (RSO) at 11:39:50.2. Numerous large pieces of the Orbiter, "Challenger," and the ET were observed to descend from the point of initial breakup and fall into the Atlantic Ocean east-northeast of the Kennedy Space Center (KSC). After Command Destruct action, the SRB's started to break into many pieces and fall into the ocean east of the Orbiter and ET impact area.

The Air Force Eastern Space and Missile Center (ESMC) was tasked by the Program Requirement Document (PRD) to provide both radar and optical tracking for Mission 51-L launch. This tasking is provided for all Space Transportation System (STS) launches in order to provide data for the performance of the Range Safety function and also to provide engineering and trajectory data to the National Aeronautics and Space Administration (NASA). The status of these systems was briefed at the Commander's Mission Briefing (see DDATF Pre-Launch Activities Team Report, Appendix J, Appendix 6) and the NASA Launch Readiness Review on January 14, 1986 (see Appendix F). The radar and optical data was used by the RSO to verify the vehicle had experienced a catastrophic breakup and both SRB's were still propulsive following the initial breakup at T+74 seconds. This data also provides the basis for water impact predictions used in the initial stages of surface recovery. The lack of a multi-object tracking system made the prediction of radar and optical data extremely difficult and, to a large measure, accounted for the lengthy search and recovery operations.

The Department of Defense Manager's STS Contingency Support Operations Center initiated a search and rescue operation on behalf of NASA. The surface search was directed by the Launch Recovery Director (LRD), in accordance with the STS Contingency Support Operations Plan dated 1 December 1985 (see Appendix G), and the Department of Defense Manager for Space Shuttle Contingency Support (DDMS). The surface search was coordinated by the United States Coast Guard (USCG) with assistance from ESMC. The surface search was terminated on February 7, 1986. The Department of the Navy was also requested to initiate preparation for an underwater salvage operation.

NASA established three areas for storage and reconstruction. The Logistics Building and an adjacent area on KSC were used for Orbiter and ET debris, respectively, and on Cape Canaveral Air Force Station (CCAFS), Hangar "O" and the EOD Range were used for SRB debris.

On January 28, 1986, Dr. William Graham, NASA Acting Administrator, appointed Mr. Jesse Moore to act as the interim 51-L Mishap Investigation Board chairman. Mr. Moore requested that Col. Edward O'Connor direct the activity of the NASA LRD and coordinate the development of the necessary search and recovery organizations required to support the recovery of the 51-L flight crew and those flight components that would provide the basis for the accident investigation. Col. O'Connor also directed the development of the recovered components preservation plan and requested Mr. Terry Armentrout of the National Transportation Safety Board (NTSB) to establish a Structural Reconstruction and Evaluation Group composed of engineering representatives from the STS element contractors, NASA, and the NTSB. Col. O'Connor provided continuing direction to these activities until formally chartered as Team Lead for the Search, Recovery, and Reconstruction Team of the Task Force on March 20, 1986.

Initial priorities for the underwater salvage operations were as follows:

1. Right-Hand Solid Rocket Booster (SRB)
2. Left-Hand SRB
3. Orbiter Crew Compartment
4. Payload

The recovery of Mission 51-L Shuttle components for support of the accident investigation activities of the Task Force was terminated on May 1, 1986. The deep water SRB recovery was terminated after the recovery of Contacts #131 and #712 which contain approximately 90% of the burn-through area of the right-hand aft field joint. This is believed to be the origin of the initial failure. Shallow water recovery was deemed to have provided sufficient material to confirm that the right-hand SRB failure was the initiating failure mode and that all other flight components failed subsequent to this failure.

Some shallow water recovery will continue in order to provide material for NASA Design Centers' Material Properties Studies.

The following pages provide a narrative of the activities leading to the recovery of debris as well as the structural reconfiguration and evaluation. The detailed source data for this report are in Enclosures 1 through 9.

Remarks:

This report utilizes the manufacturer's coordinate system. This system was selected because the reconstruction process required use of the manufacturer's drawings. Reference Figures 0 and 0-1 for the axes and coordinates.

The Photo and TV Support Team utilized the Flight Dynamics coordinate system which is illustrated in Volume 1 of their report.

III. Organizational Structure Technique

A. *Organization*

The following two charts show the top levels of the organization as charted by Rear Admiral Richard Truly and does not represent the multitude of people that participated in the Search, Recovery, and Reconstruction Task.

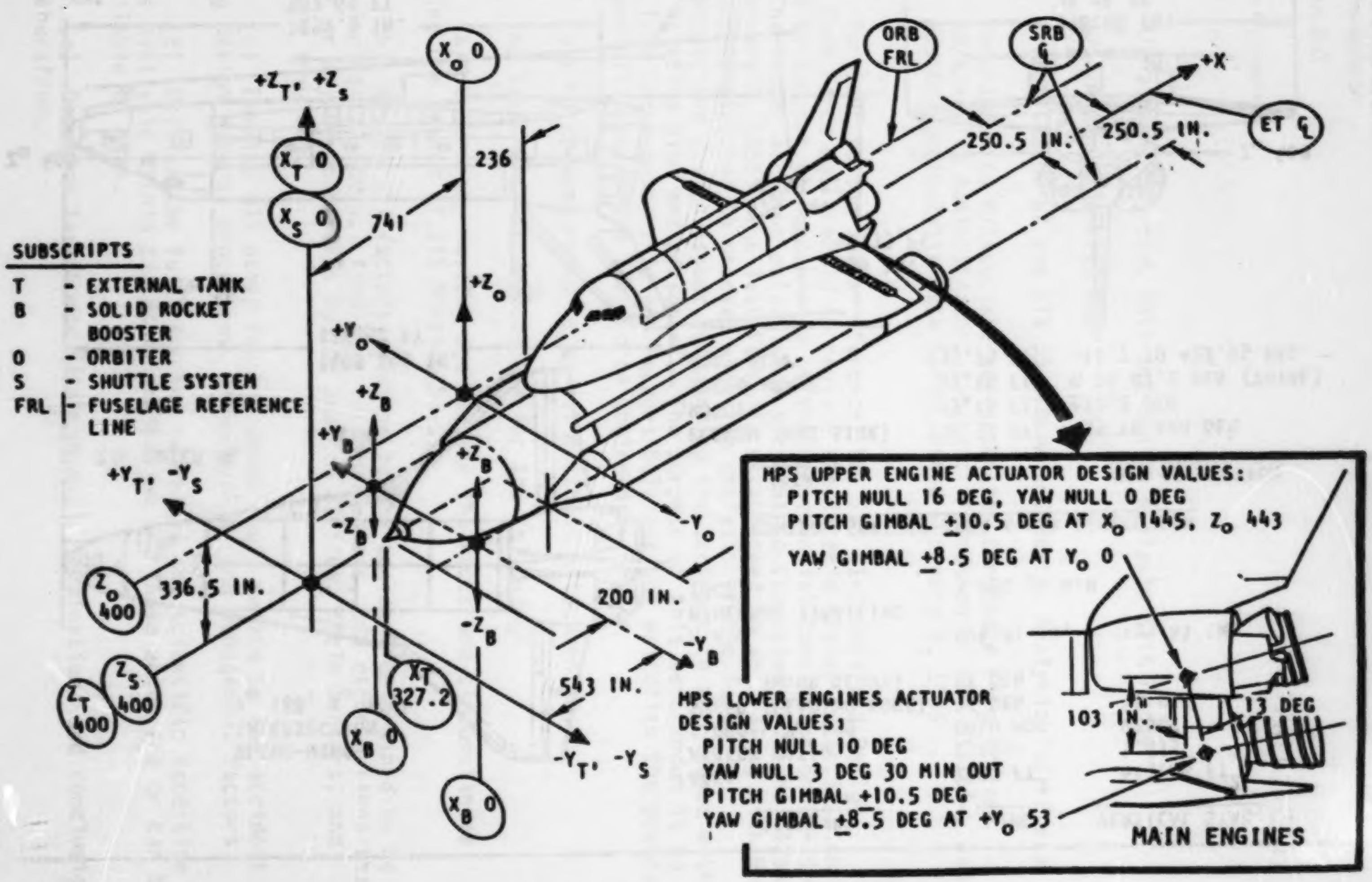
B. *Methods of Investigation*

Immediately following the mishap, the NASA LRD requested that the NASA SRB retrieval vessels proceed to the water impact location and also requested that DDMS dispatch all immediately available surface vessels and aircraft to the area of the mishap. The ESMC RSO held all aircraft and surface vessels outside of the falling debris area until entry was deemed to be safe from falling materials that could cause a hazard to the crews entering the area. Approximately one hour after the mishap, a surface search was initiated in the immediate area surrounding the water impact location of the Orbiter and ET. A large amount of Orbiter and ET debris was found floating and was recovered by surface ships. Due to the currents of the Gulf Stream, the surface search was expanded to the north and, over the next several days, extended to an area 450 nautical miles north of the initial search area.

Radar tracking data from the ESMC was utilized to determine the area for the underwater search and sonar mapping of this area commenced. The search area was subsequently expanded based on further data reduction efforts that identified a wider dispersion of Right SRB components following the Command Destruct.

Identification of individual sonar contacts was accomplished by remotely-operated vehicles (ROV's) and manned submersibles in both shallow water and deep water areas as well as divers in shallow (less than 200 ft. (61 meters)) water. This identification established the debris to be recovered as well as the priorities of recovery. Plans were developed for the recovery technique, safing, and preservation of the components.

Shuttle Coordinate Systems and Dimensions


X_O 0
+Z_T, +Z_S
X_T 0
X_S 0
741
236
ORB FRL
SRB ℄
+X
ET ℄
250.5 IN.
250.5 IN.
+Z_O
+Y_O
+Z_B
+Y_B
+Z_B
-Z_B
-Y_O
+Y_T, -Y_S
Z_O 400
336.5 IN.
Z_S 400
Z_T 400
XT 327.2
X_B 0
X_B 0
-Z_B
200 IN.
-Y_B
543 IN.
-Y_T, -Y_S
103 IN.
13 DEG
MAIN ENGINES

SUBSCRIPTS

T	- EXTERNAL TANK
B	- SOLID ROCKET BOOSTER
O	- ORBITER
S	- SHUTTLE SYSTEM
FRL	⊢ FUSELAGE REFERENCE LINE

MPS UPPER ENGINE ACTUATOR DESIGN VALUES:
PITCH NULL 16 DEG, YAW NULL 0 DEG
PITCH GIMBAL ±10.5 DEG AT X_O 1445, Z_O 443
YAW GIMBAL ±8.5 DEG AT Y_O 0

MPS LOWER ENGINES ACTUATOR DESIGN VALUES:
PITCH NULL 10 DEG
YAW NULL 3 DEG 30 MIN OUT
PITCH GIMBAL ±10.5 DEG
YAW GIMBAL ±8.5 DEG AT $+Y_O$ 53

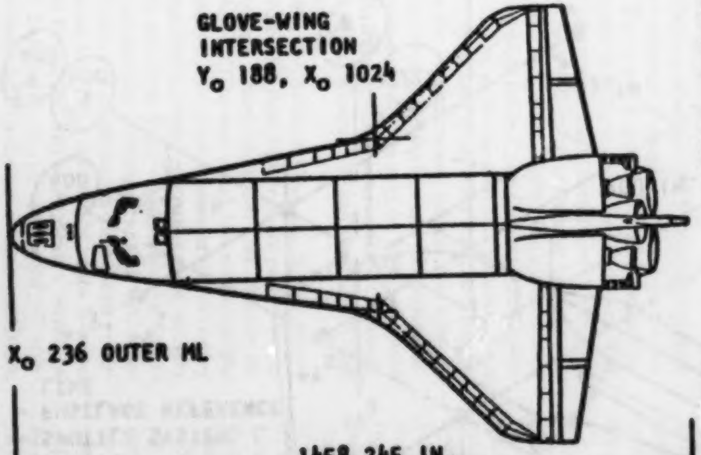
Figure 0

Orbiter Vehicle Dimensions

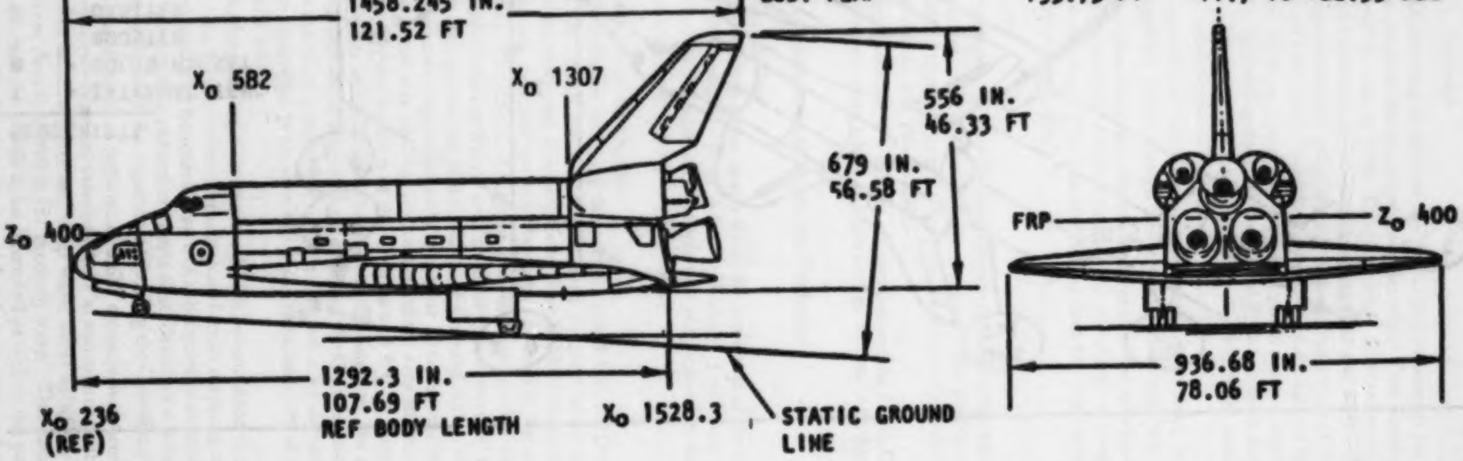
GEOMETRY	WING	VERTICAL STAB.
AREA	2690 FT^2	413.25 FT^2
ASPECT RATIO	2.265	1.675
AIRFOIL Y_o 199	0010 MOD	WEDGE
SWEEP (LEADING EDGE)	45 DEG	45 DEG
(WING GLOVE)	81 DEG	
M.A.C.	474.81 IN.	199.81 IN.
DIHEDRAL (TRAILING EDGE)	3 DEG 30 MIN	

CONTROL SURFACE AREA & MAX DEFLECTION

	AREA	MAX DEFLECTION
ELEVON (ONE SIDE)	206.57 FT^2	-35 TO +20 DEG
RUDDER	97.15 FT^2	±22.8 DEG
SPEED BRAKE	97.15 FT^2	0 TO 87.2 DEG (TOTAL)
BODY FLAP	135.75 FT^2	-11.7 TO +22.55 DEG



GLOVE-WING INTERSECTION
Y_o 188, X_o 1024
X_o 236 OUTER ML



1458.245 IN.
121.52 FT
X_o 582
X_o 1307
556 IN.
46.33 FT
679 IN.
56.58 FT
Z_o 400
FRP
Z_o 400
1292.3 IN.
107.69 FT
REF BODY LENGTH
X_o 236
(REF)
X_o 1528.3
STATIC GROUND LINE
936.68 IN.
78.06 FT

Figure 0-1

ATTACHMENT 1

NASA
National Aeronautics and
Space Administration

Washington, D C
20546

Office of the Administrator

MAR 11 1986

TO: M/Chairman, STS 51-L Data and Design Analysis Task Force

FROM: A/AD/Acting Administrator

SUBJECT: Establishment of the STS 51-L Data and Design Analysis Task Force

REF: Memorandum to M/Associate Administrator for Space Flight from AD/A/Acting Administrator, Subject: Formation of the STS 51-L Data and Design Analysis Task Force, dated February 5, 1986

1. Pursuant to the above reference, the STS 51-L Data and Design Analysis Task Force was created to replace the interim Mishap Investigation Board and to support the activities of the Presidential Commission on the Space Shuttle Challenger accident established pursuant to Executive Order No. 12546 dated February 3, 1986. The Task Force is established in accordance with NMI 8621.1D and is directed to proceed with the analysis of the facts, circumstances, and design issues surrounding the accident in accordance with the then existing plan and personnel. The purpose of this memorandum is to finalize Task Force membership and responsibilities and establish the powers and responsibilities of the Task Force Chairman.

2. Task Force membership is as set forth in Attachment A.

3. The Task Force is responsible for the following:

(a) Determine, review, and analyze the facts and circumstances surrounding the launch of STS Mission 51-L.

(b) Review all factors relating to the accident determined to be relevant including studies, findings, recommendations, and other actions that have been or may be undertaken by the program offices, field centers, and contractors involved.

(c) Examine all other factors which could relate to the accident including design issues, procedures, organization, and management factors.

(d) Utilize the full required technical and scientific expertise and resources available within the NASA institution and those which are or can be made available to NASA.

(e) Document Task Force findings and determinations and conclusions derived therefrom.

(f) In accordance with procedures established jointly with the Presidential Commission, provide information and documentation to the Commission regarding all the above or any other aspect of Task Force activities.

4. The Chairman of the Task Force is delegated the following powers and is assigned the following responsibilities:

(a) Establish such procedures for the organization and operation of the Task Force as he finds most effective; such procedures shall be part of the Task Force records.

(b) Establish procedures to assure the execution of his responsibilities in his absence.

(c) Direct or require the conduct of special tests or additional research as needed in support of the investigation.

(d) Designate such subgroups, teams, representatives, consultants, experts, liaison officers, observers, or other individuals, as required to support the activities of the Task Force. Their duties and responsibilities shall be included as part of the Task Force records.

(e) Coordinate the activities of the Task Force with the Presidential Commission in accordance with procedures established by the Commission.

(f) In coordination with the NASA Director of Public Affairs, develop a policy for the appropriate review and dissemination of information to the public concerning the Space Shuttle Challenger accident and the activities of the Task Force.

(g) Advise the Administrator concerning the organization, procedures, operations, and findings of the Task Force, and its associated activities as required.

5. All elements of NASA will cooperate with the Task Force and provide full support within their areas of responsibility.

6. By separate action, I am directing the Associate Administrator for Space Flight, consistent with the final report of the Presidential Commission, to undertake through the regular Office of Space Flight organization such reviews, studies, and supporting actions as are required to develop recommendations to me on corrective measures to be taken prior to the next STS mission with respect to hardware, operational procedures and other aspects of the STS program.

William R. Graham

William R. Graham
Acting Administrator

Enclosure

March 20, 1986

51-L DATA AND DESIGN ANALYSIS TASK FORCE

TO: E. O'Connor

FROM: Task Force Chairman

SUBJECT: Appointment of Lead; Search, Recovery and Reconstruction Team

1. By letter of March 11, 1986, Attachment 1, the Acting Administrator delegated to me, as Chairman of the 51-L Data and Design Analysis Task Force, the power to designate individuals and teams required to support the Task Force. By the same letter, he also delegated to me the power to establish procedures for organization and operation.

2. Pursuant to the delegation, I hereby establish the Search, Recovery, and Reconstruction Team of the Task Force and assign you to be the Lead for that Team. The duties, functions and responsibilities of the Team are stated in Attachment 2.

3. As Team Lead, it will be your responsibility:

a. To assign tasks to Team members and coordinate their efforts.

b. To delegate authority to the Deputy Lead to act for you as you see fit with or without your being present at the Team's regular office at KSC. The Deputy Lead will be designated by me or the Vice Chairman.

c. To coordinate the Team's activity with other Team Leads in areas of mutual interest.

d. To consult with the Task Force Vice Chairman on a regular basis on all aspects of Team activity.

e. To prepare, for consideration and approval by the Task Force, documents that memorialize in appropriate formats, the facts and analysis in the Team's assigned area.

Richard H. Truly

Attachments 2

Attachment 2

GENERAL ASSIGNMENT FOR SEARCH, RECOVERY AND RECONSTRUCTION TEAM

The Search, Recovery and Reconstruction (SRR) Team shall perform, as a priority task, the Task Force efforts needed to respond to the needs and interests of the Presidental Commission and to the support needs of the other Task Force Teams. The Team Lead and his deputy shall establish a working relationship with the other Task Force Team Leaders and deputies to provide support to specific tasks assigned by their respective charters.

The SRR Team shall undertake a priority search and recovery effort to recover critical flight components from the STS 51-L launch. The purpose of the recovery is to provide those critical hardware components that will permit the determination of the failure mode and, if possible, detailed information regarding the exact failure mechanism that occurred during the launch and flight of the STS 51-L mission. The team shall utilize the available technical methods and data sources as in the following:

1. Metric data from radar and optical instrumentation.
2. Sonar and oceangraphic data.
3. Ballistic predictions.

The SRR Team shall develop a prioritized list of components requiring recovery and upon its approval by the Task Force Vice Chairman, develop any special tools or devices required to affect the most rapid feasible recovery consistent with safety and protection of components from damage that would impede the investigative process. Upon recovery, take whatever steps that are required to maximize the utility of the recovered component for failure analysis. These steps will include photo documentation, preservation, and sampling.

The SRR Team will establish, in conjunction with the responsible design organizations the materials testing protocols required to determine component failure modes. The team will establish formal test procedures utilizing techniques such as:

1. Non Destructive Inspection
2. Limited Destructive Testing
3. Component Reconstruction
4. Avionics/GPC/Records Analysis

The SRR Team shall establish a method for using recovered components to independently verify failure tree dispositions. This independent validation shall utilize the investigative technique developed by the NTSB and other organizations to confirm the analytically derived fault tree disposition of the other Task Force teams. This validation effort may require the search and recovery of specific vehicle components to provide positive validation of the major failure mode and possible related failure mechanisms.

The SRR Team will establish technical representation in selected test programs in order to assist in the technical development of test program and the validation of its performance. This effort is required to insure that test results can be properly correlated with conditions found in recovered components.

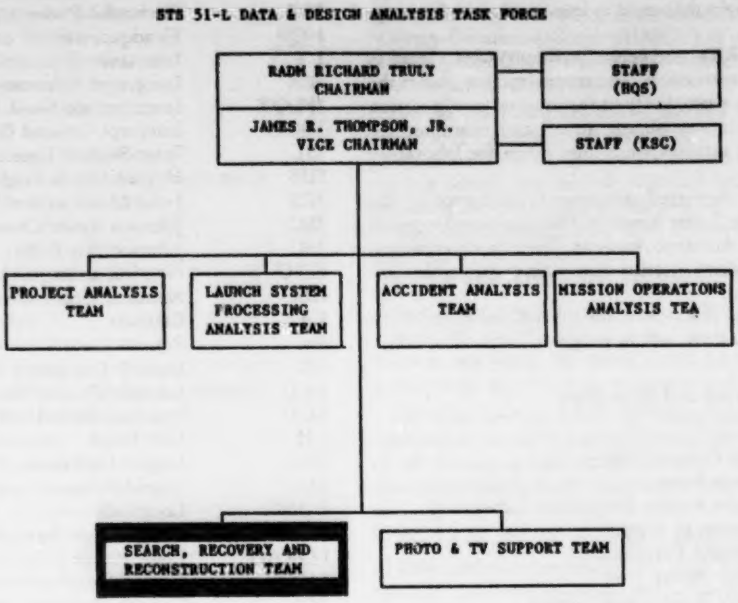
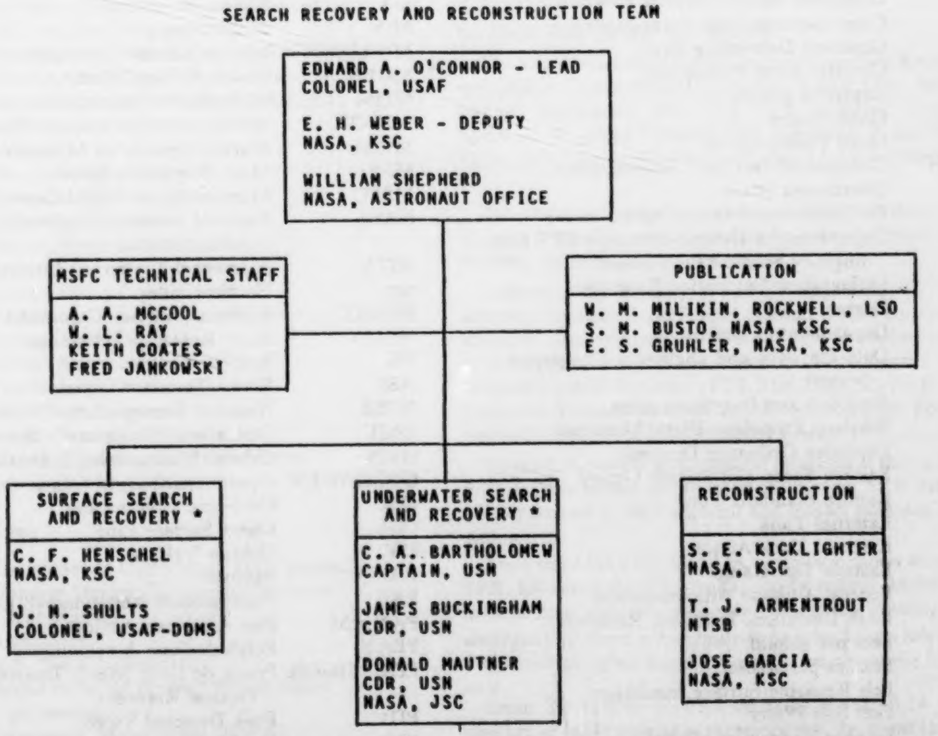

STS 51-L DATA & DESIGN ANALYSIS TASK FORCE
RADM RICHARD TRULY CHAIRMAN
JAMES R. THOMPSON, JR. VICE CHAIRMAN
STAFF (HQS)
STAFF (KSC)
PROJECT ANALYSIS TEAM
LAUNCH SYSTEM PROCESSING ANALYSIS TEAM
ACCIDENT ANALYSIS TEAM
MISSION OPERATIONS ANALYSIS TEA
SEARCH, RECOVERY AND RECONSTRUCTION TEAM
PHOTO & TV SUPPORT TEAM

CHART 1


SEARCH RECOVERY AND RECONSTRUCTION TEAM
EDWARD A. O'CONNOR - LEAD
COLONEL, USAF
E. H. WEBER - DEPUTY
NASA, KSC
WILLIAM SHEPHERD
NASA, ASTRONAUT OFFICE
MSFC TECHNICAL STAFF
A. A. MCCOOL
W. L. RAY
KEITH COATES
FRED JANKOWSKI
PUBLICATION
W. M. MILIKIN, ROCKWELL, LSO
S. M. BUSTO, NASA, KSC
E. S. GRUHLER, NASA, KSC
SURFACE SEARCH AND RECOVERY *
C. F. HENSCHEL
NASA, KSC
J. M. SHULTS
COLONEL, USAF-DDMS
UNDERWATER SEARCH AND RECOVERY *
C. A. BARTHOLOMEW
CAPTAIN, USN
JAMES BUCKINGHAM
CDR, USN
DONALD MAUTNER
CDR, USN
NASA, JSC
RECONSTRUCTION
S. E. KICKLIGHTER
NASA, KSC
T. J. ARMENTROUT
NTSB
JOSE GARCIA
NASA, KSC

* Naval operations for underwater search and recovery were directed by LRD and DDMS with operation control maintained by the team lead.

CHART 2

The recovery was accomplished by the divers and submersibles. The recovered parts were delivered to impound areas for possible reconstruction.

The Orbiter, ET, SRB's, and cargo (payloads) were placed in separate areas for reconstruction. The reconstruction placed the components in as close a proximity to the original configuration as possible. The debris was photographed and examined for physical evidence and samples were then taken for laboratory examination.

The analyses of the recovered components conducted by the National Transportation Safety Board (NTSB) were used to verify the conclusions of the Accident Analysis Team in determining the specific failure modes/scenarios dispositions (probable, improbable, and possible).

At the time of writing this report, the identification, recovery and reconstruction tasks are still in progress.

IV. Definition of Terms and Acronyms

A. *Acronyms*

ACO	Aircraft Control Officer
AFB	Air Force Base
AFRPL	Air Force Rocket Propulsion Laboratory
AOS	Acquisition of Signal
AP	Ammonium Perchlorate
APU	Auxiliary Power Unit
ARS	Auxiliary Rescue and Salvage
ARTC	Air Route Traffic Control
ASE	Airborne Support Equipment
ASR	Auxiliary Submarine Rescue
BET	Best Estimate of Trajectory
BRD	Booster Recovery Director
BSM	Booster Separation Motors
CASP	Computer Assisted Search Program
CCAFS	Cape Canaveral Air Force Station
CDF	Confined Detonating Fuse
CEP	Circular Error Probability
cg	Center of gravity
CG	Coast Guard
CGC	Coast Guard Cutter
CINCLANT	Commander-in-Chief, Atlantic Fleet
CW	Continuous Wave
dBsm	Decibels relative to one square meter
DDMS	Department of Defense Manager STS Contingency Support Operations
DDT	Deflagration-Detonation Transition
DEG	Degree
DOD	Department of Defense
DPDE	Data Playback and Digitizing Equipment (video)
E&I	Electrical and Instrumentation
EPDM	Ethylene Propylene Diene Monomer
EOD	Explosive Ordnance Disposal
ESMC	Eastern Space and Missile Center
EST	Eastern Standard Time
ET	External Tank
ETA	External Tank Attach
ETR	Eastern Test Range
FAA	Federal Aviation Administration
FDIR	Fault Detection, Isolation, Recovery
fps	Feet per second
fps	Frames per second
FRSI	Felt Reusable Surface Insulation
FSW	Feet Salt Water
FTD	Foreign Technology Division
GH_2	Gaseous Hydrogen
GMT	Greenwich Mean Time
GN&C	Guidance, Navigation, and Control
GPS	Global Positioning System
GO_2	Gaseous Oxygen
HAZ	Heat Affected Zone
HP	Hewlett Packard
HPU	Hydraulic Power Unit
HQS	Headquarters
I/T	Intertank
IEA	Integrated Electronics Assembly
IFLOT	Intermediate Focal Length Optical Recorder
IGOR	Intercept Ground Optical Recorder
ISL	Inter Surface Line
IUS	Inertial Upper Stage
JCS	Joint Chiefs of Staff
JSC	Johnson Space Center
JSL	Johnson Sea Link
KNOTS	Nautical miles per hour
KSC	Kennedy Space Center
LAT	Latitude
lbs	Pounds
LC	Launch Complex
LCD	Launch Countdown
LCU	Landing Craft Utility
LH	Left Hand
LH_2	Liquid Hydrogen
LO_2	Liquid Oxygen
LONG	Longitude
LORAN	Long Range Navigation
LORAC	Long Range Accuracy
LOS	Loss of Signal
LOV	Loss of Visibility
LPS	Launch Processing System
LRD	Launch Recovery Director
LRD	Landing Recovery Director
LSC	Linear-Shaped Charge
LSO	Launch Services Organization
LWT	Light Weight Tank
m/s	Meters per second
M/V	Motor Vessel
MARISAT	Marine Satellite Communications System
MCBR	Mobile C-Band Radar
MDM	Multiplexer-Demultiplexer
MIGOR	Mobile Intercept Ground Optical Recorder
MOM	Marine Operations Manager
MPS	Main Propulsion System
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NITE	N-Internal Trajectory Estimation Program
nm	Nautical mile
NMCC	National Military Command Center
NR-1	Navy Research Submarine
NS	Nuclear Shuttle
NSI	NASA Standard Initiator
NTSB	National Transportation Safety Board
OMI	Operations Maintenance Instructions
OMS	Orbital Maneuvering Subsystem
OPCONCEN	Operations Control Center
OSC	On-Scene Commander
OSL	Outer Surface Line
OV	Orbiter Vehicle
P/L	Payload
PAL	Protuberance Aerodynamic Load
PAN AM	Pan American Airlines
PBAN	Polybutadiene Acrylonitrile
PDL MIGOR	Ponce de Leon Metric Intercept Ground Optical Recorder
PDV	Peak Detected Video
PIC	Pyro Initiator Circuit
PRF	Pulse Recurrence Frequency
R/V	Research Vehicle
RADM	Rear Admiral
RAE	Range/Azimuth/Elevation
RAPP	Radar Position Program (Computer Program 331)

RAPS	Right Aft Propulsion System
RCA	Radio Corporation of America
RCS	Radar Cross Section
RCS	Reaction Control System
RF	Radio Frequency
RGA	Rate Gyro Assembly
RH	Right Hand
ROM	Rough Order of Magnitude
ROTI	Recording Optical Tracking Instrument
ROV	Remote Operating Vehicle
RSB	Rudder Speed Brake
RSO	Range Safety Officer
RSS	Range Safety System
RTI	Range/Time/Intensity (video)
S/N	Serial Number
S/N	Signal-to-Noise Ratio
SAR	Search and Rescue
SARTEL	Search and Rescue Telephone Network
SEM	Scanning Electron Microscope
SITREPS	Situation Reports
SLA	Sprayable Light Ablator
SOC	Support Operations Center
SOG	Speed Over Ground
SONAT	Southern Natural Coast Oil Company
SPC	Shuttle Processing Contract
SRB	Solid Rocket Booster
SRM	Solid Rocket Motor
SRO	Supervisor Range Operations
SSME	Space Shuttle Main Engine
SRR	Search, Recovery and Reconstruction
STA	Station
STS	Space Transportation System
SUPSALV	Supervisor of Salvage (USN)
TCAR	Tracking Camera Automatic Reduction (Computer Program 017)
TDRS	Tracking and Data Relay Satellite
TDRSS	Tracking and Data Relay Satellite System
TPS	Thermal Protection System (SRB, ET, or Orbiter)
TV	Television
TVC	Thrust Vector Control
UCS	Universal Camera Site
UHF	Ultra High Frequency
US	United States
USAF	United States Air Force
USCG	United States Coast Guard
USCGC	United States Coast Guard Cutter
USN	United States Navy
USS	United States Ship
VAFB	Vandenberg Air Force Base
VHF	Very High Frequency
WGS	World Geodetic System
WSMC	Western Space and Missile Center
x	Power of magnification

B. *Definition of Terms*

Fish	Towed Sonar Cylindrical Tube (sensor)
Pinger	Homing Device (Short-range acoustic transmitter)
Starboard	Right Side
Tracor	U.S. Navy Contractor
WD-40	Brand name of product for corrosion protection
Zulu	Greenwich Mean Time (GMT)

V. Report Summaries

A. *Surface Search*

During the first few minutes following the Mission 51-L Shuttle Mishap, the DOD Manager's STS Contingency Support Operations Center (SOC) alerted appropriate search and rescue operations and established communications with the National Military Command Center (NMCC) as well as the Joint Chiefs of Staff (JCS). The JCS formed a Shuttle Response Cell which was briefed on the situation.

During the first fifteen (15) minutes following the mishap, search and rescue aircraft and ships were dispatched to holding points short of the safety zone established for falling debris. During this period, one aircraft reported sightings of falling debris impacting the ocean surface. The two SRB retrieval vessels, Liberty Star and Freedom Star, were directed from launch support positions to the impact area.

At 1737Z (1237 EST), the Range Safety Officer gave a clearance for aircraft to enter the safety area.

By 2130Z (1630 EST), a major Search and Rescue (SAR) effort was requested. By 2400Z (1900 EST), twelve (12) aircraft and eight (8) ships were participating in the area of debris impact.

On February 5, 1986, the Coast Guard sent a notice to mariners declaring the search area a safety area, which suspended all fishing operations in the area. This was done because numerous scallop boats reported finding Shuttle debris in their nets.

The Surface Search and Rescue effort continued until February 7, 1986. Debris recovered by the ships assigned to the effort was brought into Port Canaveral and off-loaded. Debris found off the coast of Georgia and South Carolina was returned to the Cape Canaveral Air Force Station (CCAFS).

During the period of January 28, 1986 through February 7, 1986, the Search and Rescue Operation was simultaneously supported with as many as 14 ships and 11 aircraft. The Coast Guard stated, "The operation was the largest surface search in which they had participated."

B. *Metric Data* (Radar and Optics)

The source materials for this section were two Eastern Space and Missile Center (ESMC) reports, "Radar Data Analysis and Impact Estimation for STS 51-L Debris," Report No. 82-SR-86-06, dated 7 March 1986, Enclosure 2, and "STS 51-L Right SRB," Report 82-SR-86-07, dated 4 April 1986, Enclosure 3.

The prime purpose of evaluation of the metric data (radar/optics) was to provide impact locations for debris recovery and, when possible, identify the tracked object.

Following the breakup of the External Tank (ET) at T+74 seconds, the right Solid Rocket Booster (SRB) continued under thrust for approximately 37 seconds. It was tracked continuously by Radar 1.17 and the Ponce de Leon Metric Integrated Ground Optical Recorder (PDL MIGOR). Radar 0.14 and the Universal Camera Site (UCS) #15 Intermediate Focal Length Optical Tracker (IFLOT) tracked briefly.

Figure 1 shows the geographical locations of the radar and optical stations as well as the track of the right SRB Aft skirt with a short section of SRB segment and impact points of other SRB debris.

Analysis of the PDL MIGOR video tape shows the right-hand SRB, following the ET breakup, to be rolling clockwise viewed from aft approximately once every 10 seconds. Possibly this period decreased by about 1.5 seconds during the 37 seconds of powered flight indicating an angular acceleration about the longitudinal axis.

From T+93.6 to T+95.8 seconds, Radar 0.14 detected a number of small objects separating from the main target. None of these objects was visible to the optics sites or on the radar boresight video tape. Enough data could be extracted to permit a trajectory estimate to be made for one of these objects, designated RD on Figure 1. Impact was at approximately T+398 seconds, and the separation speed relative to the main SRB body was on the order of 60 meters per second (m/s).

At T+110.3 seconds, Range Safety issued a command destruct to the SRB's. The shock wave from the destruct explosion of the right SRB was visible on the UCS-15 E-705 16mm camera, permitting a computed estimate of the explosion at time T+110.275 seconds. The propagation speed of the shock wave was on the order of 1,000 m/s during the first few hundredths of a second with the expansion slowing to essentially zero within 0.1 second.

Following the command destruct, the SRB separated into a number of fragments. Optical resolution was not sufficient to permit the identification of these fragments. Radar 1.17 and PDL MIGOR continued to track a large piece later identified as part of the aft segment and skirt. A number of smoke trails, possibly two dozen small (pinpoint) glowing objects and four bright glowing objects, could be seen on the UCS-15 IFLOT 70mm film. The four bright glowing objects and possibly three smoke trails were also seen on the PDL MIGOR video tape. The radar boresight video tape showed no visible object after the command destruct.

Because the smoke trails are at the limit of the PDL MIGOR video resolution, first priority was given to the three bright glowing objects not tracked by Radar 1.17. Triangulation on these objects (RA, RB, and RC) was possible for periods of four (4) to six (6) seconds, and impact trajectories have been generated. Figure 1 is a map showing the ground traces of the tracked (solid) and projected (dotted) trajectories. Separation speeds relative to the booster aft segment ranged from 45 m/s to 120 m/s.

From T+115 to T+141 seconds, an object flashing twice per second was in the PDL MIGOR field of view. Although it appears near the tracked segment, it cannot be positively linked to the right SRB.

The Federal Aviation Administration (FAA) radar observations cannot be positively associated with the right or the left SRB. The six impact estimates may be from either source, but Objects 2, 5, 6, and 7 appeared more likely to be from the right SRB.

Estimated impact locations of nine objects were determined using the ESMC radar data only. The impact locations are shown on Figure 2.

1. Object A's impact location was of prime importance as it represented debris from the right SRB.

2. Two objects (F and G) were parachutes believed to have been picked up during the surface search. *Note*: One drogue chute was recovered during the surface search. The right-hand main chutes were recovered with the right-hand SRB forward skirt.

3. Two objects (B and D) were believed to be sizeable (2 to 5 meters, 6 to 16 feet) based on radar boresight recordings and were believed to be dense based on their early impact times.

4. One object (K) was relatively dense but the cross-section was less than 0.1 square meter (1.1 square feet).

5. Two objects (C and I) had moderately slow final descent rates of about 134 feet per second (41 meters per second) with Object C having a relatively large cross-section.

6. Object H was of little interest for recovery operations since it appeared to be a small, light object which may very well have floated after impact.

Both of the reports estimated impact locations of Shuttle-related debris thought to be from the SRB's. Data from both reports support the impact location of the right SRB aft skirt with partial segment attached, reference Figure 2, Object "A" and Figure 1, Point "R".

C. *Sonar Mapping*

1. The Supervisor of Salvage, Charles A. Bartholomew, Captain, U.S. Navy, with the assistance of the SRB Incremental Recovery Group lead by Alexander A. McCool, Director, Structures and Propulsion Laboratory, MSFC, directed the Search and Recovery Operation. This section and the next two sections describe the methods utilized during this operation. A more detailed description is contained in Enclosure 4, Search, Classification, and Recovery, and Enclosure 5, SRB Incremental Recovery Planning.

The planning for an underwater salvage operation is dependent upon a changing set of contact data, priorities, and environmental conditions. By utilizing the data available, the proper assets were acquired and effectively utilized (see Table 1 for assets used). The search, contact classification, and recovery phases were accomplished concurrently.

Table 1. Search and Salvage Vessel Assets and Capabilities

Platform	Ship Specifications	Search/Salvage Assets
FREEDOM STAR (NASA) Searching[1] 2/8/86 – Present	Length: 176 Feet Beam: 37 Feet Draft: 12 Feet Clear Deck Space: 225 Sq-m Max Speed: 17 Knots	GPS/LORAN-C NAVIGATION Side Scanning Sonar – Max Depth of 700 Feet Through 4/1/86 – Max Depth of 3,000 Feet After 4/1/86
LIBERTY STAR (NASA) Searching[1] 2/8/86 – Present	Length: 176 Feet Beam: 37 Feet Draft: 12 Feet Clear Deck Space: 225 Sq-m Max Speed: 17 Knots	GPS/LORAN-C NAVIGATION Side Scanning Sonar – Max Depth of 3,000 Feet
INDEPENDENCE (NASA) Classification[1] Recovery[1] 2/8/86 – Present	Length: 199 Feet Beam: 40 Feet Draft: 15 Feet Clear Deck Space: 390 Sq-m Max Speed: 13 Knots Lifting Capacity: 4.5 Tons	GPS/LORAN-C NAVIGATION DEEP DRONE: – Unmanned ROV – Max Depth 6,000 Feet – Sonar, High Resolution 360 DEG, for contact localization – Video Cameras (3) – Still Photo Cameras – Two Manipulators – Duration limited only by surface support platform

LCU–RANGE BOAT (UASF) Searching[1] Classification[1] Recovery[1] 2/8/86–Present	Length: 126 Feet Beam: 24 Feet Draft: 6 Feet Clear Deck Space: 130 Sq-m Max Speed: 8 Knots Lifting Capacity: 10 Tons	LORAC (A) NAVIGATION SCANNING SONAR, MESOTECH –Max Depth 200 Feet DIVERS: –Air to 100 Feet
USS PRESERVER (US NAVY) Classification[1] Recovery[1] 2/8/86–Present	Length: 201 Feet Beam: 43 Feet Draft: 13 Feet Clear Deck Space: 300 Sq-m Max Speed: 14.8 Knots Lifting Capacity: –8 Tons Forward –10 Tons Aft Recompression Chamber Air Diving Support System	GPS/LORAN-C NAVIGATION DIVERS (22) –Air Diving to 190 Feet –Diver Held Video Camera –Diver Held 35mm Camera
USS OPPORTUNE (US NAVY) Classification[2] Recovery[1] 4/5/86–Present	Length: 214 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3,440 Ft^2 Max Speed: 15.0 Knots Lifting Capacity: –20 Tons Forward –12 Tons Aft Recompression Chamber Air Diving Support System	GPS/LORAN-C NAVIGATION [3] SCANNING SONAR MESOTECH: [3] –Max Depth of 200 Feet DIVERS (22): –Air Diving to 190 Feet –Diver Held Video Camera –Diver Held 35mm Camera SCORPI: [3] –Employed 4/22/86–Present –Unmanned ROV –Max Depth 3,000 Feet –Forward Speed 4 Knots –Sonar Range 4 to 400 Feet –Video Cameras (2) –Still Photo Camera –One Manipulator
USS SUNBIRD (US NAVY) Classification[2] Recovery[2] NR-1 Support[2] 2/20/86–3/18/86 3/31/86–4/17/86	Length: 252 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3,440 Ft^2 Max Speed: 15 Knots Lifting Capacity: 10 Tons Recompression Chamber Diving Support Capability: –Air and Mixed Gas (HEOX) Submarine Rescue Capability	GPS/LORAN-C NAVIGATION [3] SCANNING SONAR, MESOTECH: [3] –Max Depth of 200 Feet DIVERS (24): – Air Diving to 190 Feet –HEOX Diving to 300 Feet –Diver Held Video Camera –Diver Held 35mm Camera
NR-1 RESEARCH SUB (US NAVY) Wide Area Search[2] Classification[2] 2/20/86–3/18/86 3/31/86–4/17/86	Length: 137 Feet Beam: 16 Feet Draft: 15 Feet Clear Deck Space: N/A Max Speed: –4.5 Knots Surface –3.5 Knots Submerged Sample Collection Baskets, 2 Lifting Capacity: –Manipulator, 1,000 lbs –Object Recovery System, 500 lbs	NAVIGATION: –Dead Reckoning w/Digital Computer (Accuracy 1.5% Distance Traveled) –4 Deployable Transponders (Used to mark contacts and to update location) Side Looking Sonar: –600 Feet Search Width With 1 Foot Resolution –2,400 Feet Search Width With 4 Feet Resolution Forward Looking Sonar: –3 to 1,500 Yard Range –1 to 30 Yards Resolution Sub-Bottom Profiler Eleven Video Cameras Four Still Photo Cameras

USS KITTIWAKE (US NAVY) Recovery[2] 4/11/86 – 4/22/86	Length: 252 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3,440 Ft^2 Max Speed: 15 Knots Lifting Capacity: 10 Tons Recompression Chamber Diving Support Capability: – Air and Mixed Gas (HEOX) Submarine Rescue Capability	GPS/LORAN-C NAVIGATION [3] SCANNING SONAR, MESOTECH: [3] – Max Depth of 200 Feet DIVERS (24): – Air Diving to 190 Feet – HEOX Diving to 300 Feet – Diver Held Video Camera – Diver Held 35mm Camera
STENA WORKHORSE (SUPSALV) Classification[2] Recovery[2] 2/28/86 – 5/1/86	Length: 320 Feet Beam: 61 Feet Draft: 20 Feet Clear Deck Space: 6,030 Ft^2 Max Speed: 17 Knots Lifting Capacity: 100 Tons Dynamic Positioning System Helideck Hospital, 2-Bed Saturation Diving System – 1,500 Feet	GPS/LORAN-C NAVIGATION [3] GEMINI: [3] – Unmanned ROV – Max Depth 5,000 Feet – Forward Speed 3 Knots – Sonar Range 4 to 200 Ft – Video Cameras (3) – Still Photo Cameras (3) – Two Manipulators With 1,500 lbs Lift Capacity
SEWARD JOHNSON (SUPSALV) Classification[2] Recovery[2] 2/21/86 – 4/19/86	Length: 176 Feet Beam: 36 Feet Draft: 12 Feet Clear Deck Space: 3,120 Ft^2 Max Speed: 14 Knots Lifting Capacity: 5 Tons Sub-Handling System: 18 Tons Ship Stabilizing System Precision Station-Keeping: – 360 DEG Bow & Stern Thrusters	GPS/LORAN-C NAVIGATION [3] SEALINK II: [3] – Manned Submersible – Max Depth 2,640 Feet – Sonar – Video Cameras (3) – Manipulator
EDWIN LINK (SUPSALV) Classification[2] Recovery[2] 3/27/86 – 5/1/86	Length: 123 Feet Beam: 27 Feet Draft: 11.5 Feet Clear Deck Space: 1,440 Ft^2 Max Speed: 13 Knots Lifting Capacity: 5 Tons Sub-Handling System: 12 Tons Decompression Chamber: – Max Depth 750 Feet Ship Stabilizing System Bow Thruster	GPS/LORAN-C NAVIGATION [3] SEALINK I: [3] – Manned Submersible – Max Depth 2,640 Feet – Sonar Range, 2,000 Feet – Video Cameras (3) – Manipulator
G.W. PIERCE II (SUPSALV) Searching[2] 2/25/86 – 4/1/86 Recovery[2] 4/1/86 – 4/19/86	Length: 158 Feet Beam: 30 Feet Draft: 9 Feet Clear Deck Space: 2,390 Ft^2 Max Speed: 10 Knots Lifting Capacity: 10 Tons	GPS/LORAN-C NAVIGATION [3] Side Scanning Sonar: [3] – Max Depth 3,000 Feet Through 4/1/86 DIVERS (12): – Employed 4/1/86-5/1/86 – Diver Held Video Camera – Diver Held 35mm Camera
PAUL LANGEVIN III (SUPSALV) Searching[2] 3/13/86 – Present	Length: 144 Feet Beam: 29 Feet Draft: 9 Feet Clear Deck Space: 2,600 Ft^2 Max Speed: 13 Knots Lifting Capacity: 10 Tons	GPS/LORAN-C NAVIGATION [3] Side Scanning Sonar:[3] – Max Depth 500 Feet
ELIMINATOR (SUPSALV) Support Craft for Personnel and Cargo X-fer[2]	Length: 70 Feet Beam: 19 Feet Draft: 5 Feet Clear Deck Space: 700 Ft^2 Max Speed: 20 Knots	LORAN-C NAVIGATION

PELICAN PRINCESS (SUPSALV) Support Craft for Personnel and Cargo X-fer[2]	Length: 90 Feet Beam: 26 Feet Draft: 6 Feet Clear Deck Space: 950 Ft^2 Max Speed: 18 Knots	LORAN-C NAVIGATION

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[1] Primary Employment

[2] Vessel Employment Phases

[3] SUPSALV Supplied Assets

The Supervisor of Salvage held daily meetings with NASA, DDMS, ESMC, and Coast Guard personnel to determine priorities and deployment of assets. All phases of the operation were discussed with alternatives planned if conditions changed.

Radar data (both ESMC and FAA) were used to establish the basic search area, a parallelogram 10 miles by 25 miles, 5 miles on each side of the major radar tracks. Water depth was just under 100 feet to approximately 1200 feet. The area was completely within the Gulf Stream. The area was later expanded to include the entire right and left hand SRB debris fields based on refined analyses of trajectory data (reference Figure 1). The expanded search area was 480 square nautical miles (307,200 acres) in size. Figure 3 is a map of the search area.

2. The Global Positioning System (GPS) was selected to be used as the primary navigation system. LORAN-C and LORAC-A were also used but corrected using GPS as a standard to adjust for inaccuracies between systems.

The search area was mapped for targets by side scan sonar. This is a device towed by a ship 15 meters (49 feet) above the ocean bottom at a constant speed (between 2 to 4 knots). In order to maintain a constant speed while moving within the Gulf Stream, most mapping runs were made north to south against the current. This extended the operation because no data was gathered on the return trip (to the north).

Search lines 5 seconds longitude apart (135 meters, 148 yards) were used to provide sufficient overlap of bottom surface coverage. Sonar scan width was 300 meters (328 yards). This provides for 118% overlap. This is done to prevent any voids based on navigation systems inaccuracies, sea conditions, and winds. Through May 1, 1986, a total of 691 contacts have been identified using side scan sonar.

D. *Contact Classification*

Contact classification was accomplished by documentation and small debris provided by divers (many), remotely-operated submersibles (2), and manned submersibles (2). This documentation consisted of still photographs, video tapes, audio descriptions from manned submersibles, and diver descriptions. Small pieces from debris fields were recovered in an effort to determine a possible general location of adjacent components. Each contact was classified as Shuttle-related, non-Shuttle-related, or unconfirmed. The Shuttle-related were put into categories of each element: Orbiter, ET, Right SRB, and Left SRB.

The majority of the contacts were classified as non-Shuttle-related. These items were Geological, such as shells, coral ridge lines, fish, debris of previous unsuccessful launches from CCAFS, and discarded equipment from vessels using the shipping lane, such as refrigerator, 55-gallon drums, coils of wire.

Through May 1, 1986, 490 contacts have been classified; 408 contacts have been non-Shuttle, while 82 contacts have been Shuttle-related (5 to 1 ratio).

E. *Recovery*

During the contact phase, photos, video tapes, and divers' logs were examined to determine what techniques were to be used for recovery. Special tools were designed and fabricated. The variety of tools ranged from large baskets to contain small pieces in dense debris fields to attach fittings used to lift pieces of SRB weighing up to 15 tons.

Special individual plans were prepared to recover pieces of SRB. This was done to prevent or minimize any handling damage and provide instructions for preservation to prevent additional corrosion. These plans are listed in Enclosures 4 and 5 with an example included in Enclosure 5.

Again, the daily meetings held by SUPSALV were used to establish the priorities and dispatch assets for contact recovery. This was invaluable as it provided a forum to redirect assets as priorities changed.

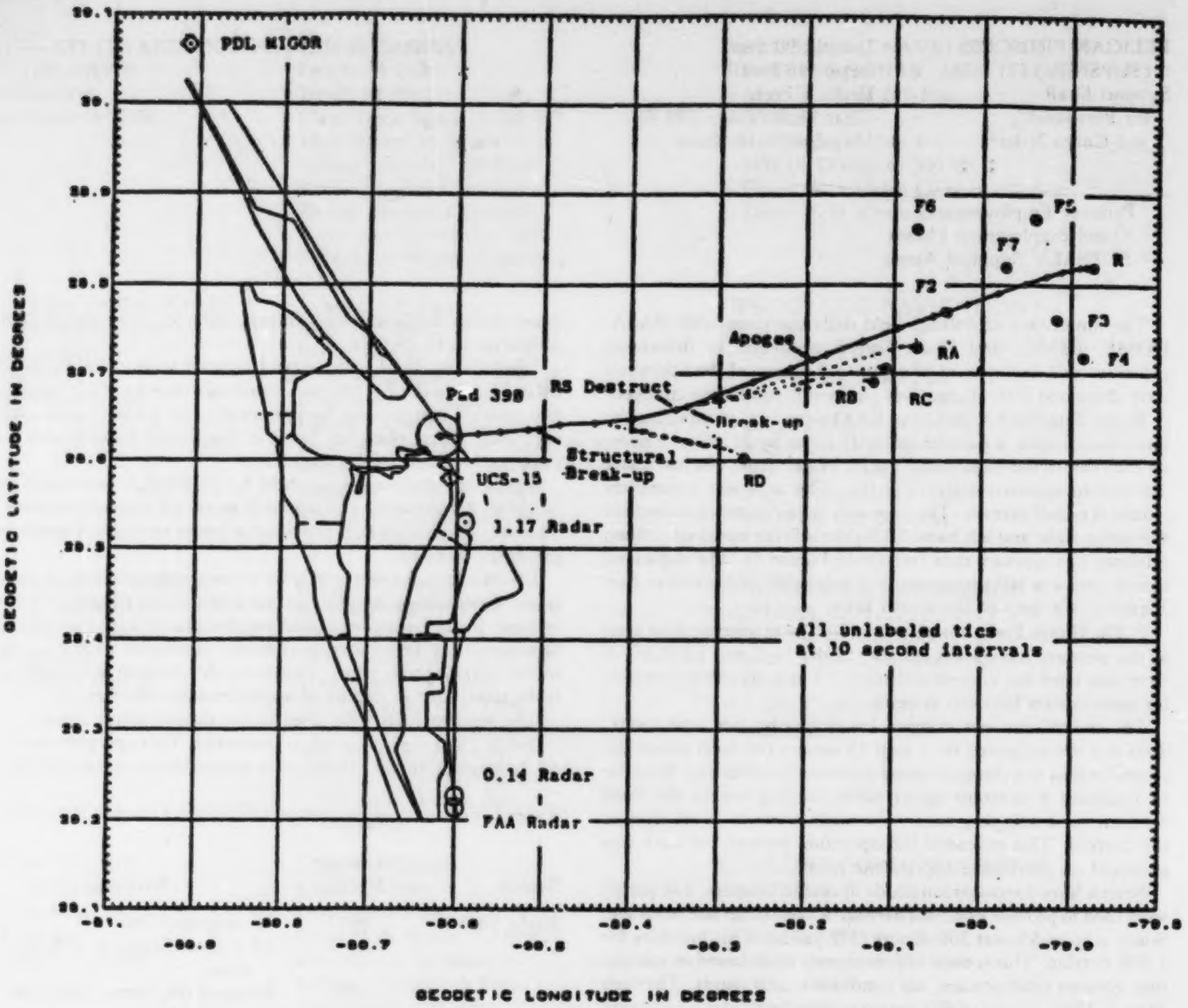
Divers were used extensively for recovery operations in shallow water. Only surface-supplied air and scuba diving techniques were utilized. Surface-supplied mixed gas (helium/oxygen) and saturation mixed gas (helium/oxygen) diving techniques were not used in the initial search effort. However, this technique is planned to be used later in depths of approximately 300 feet.

The submersibles were used in the deeper water areas.

Table 2 lists the major debris recovered. This operation utilized the largest number of assets ever assembled for marine salvage.

Table 2. Summary of Underwater STS 51-L Contacts Recovered

System	Contact Number	Remarks
Right SRB	0021	Aft Segment Skirt
	0131	Aft Center Segment w/Burn Area
	0195	Forward Aft Center Segment
	0292	Forward Aft Segment
	0301	Aft Forward Segment
	0325	Aft Center Segment
	0433	Aft Center Segment
	0502	Forward Center Segment
	0538	Forward Skirt and Parachute
	0579	Aft Segment
	0615	Forward Center Segment
	0712	Aft Segment w/Burn Area
Orbiter	0008	Hydraulic Lines
	0010	Engine Parts
	0023	Engine Parts
	0030	3' Cable Tray Exit
	0066	Main Orbiter Engine Nozzle
	0068	Aft Fuselage
	0071	Miscellaneous Small Hardware
	0072	Miscellaneous Medium Hardware
	0077	Medium Sidewall Piece
	0078	Medium Cone Shape
	0192	Large Hydrazine Tank
	0520	Left Aft Fuselage
	0530	Vertical Stabilizer
	0555	External Large Piece
	0558	Engine Nozzle
	0564	Aft Cargo Hold



RIGHT SRB AND FAA RADAR IMPACTS

NOTES:

1) F2 through F7 represent impact points derived from FAA Radar.

2) R, RA through RD represent impact points derived from ESMC radar and optics.

Figure 1

IMPACTS FROM RADAR DATA

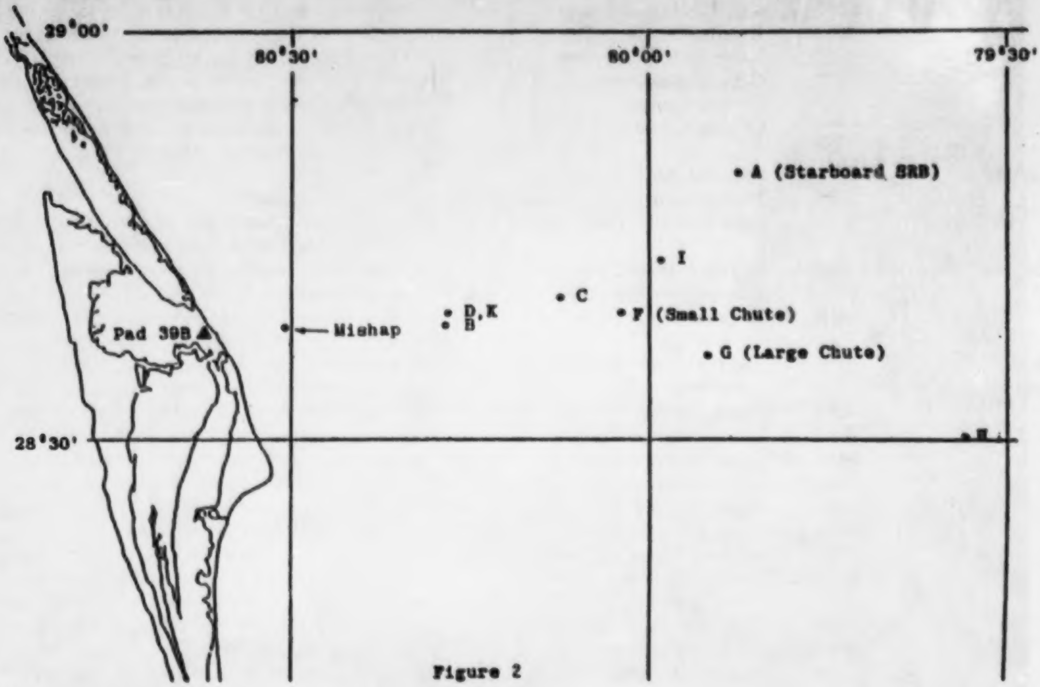

29°00'
80°30'
80°00'
79°30'
A (Starboard SRB)
I
C
D,K
B
F (Small Chute)
Pad 39B
Mishap
G (Large Chute)
28°30'
H

Figure 2

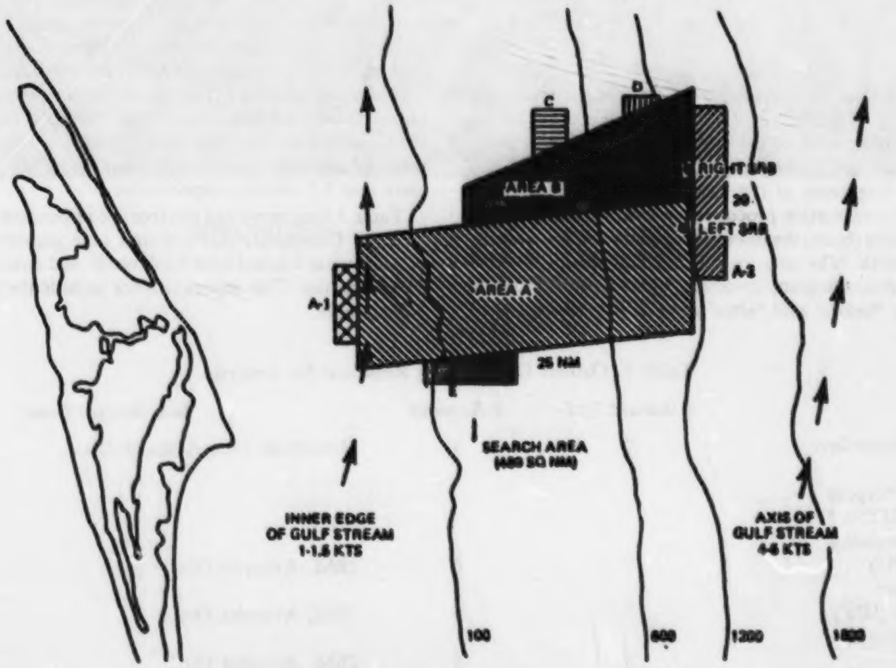

C
D
AREA B
RIGHT SRB
20
LEFT SRB
A-2
A-1
AREA A
25 NM
SEARCH AREA
(480 SQ NM)
INNER EDGE
OF GULF STREAM
1-1.5 KTS
AXIS OF
GULF STREAM
4-6 KTS
100
600
1200
1800

Figure 3. Search Area

	0566	Right Wing
	0567	Electronics and Wiring
	0568	Left Fuselage Sidewall
	0572	External Medium Piece
	0595	Large Left Wing Piece
	****	Crew Compartment
	****	Orbiter Cargo
	****	Orbiter Cargo
Left SRB	0011	Forward Aft Segment
	0026	Forward Aft Center Segment
	5124	SRB External Tank Strut
External Tank	0003	External Small Pieces
	0004	External Medium Piece
	0029	External Large Piece
Booster, Unknown Side	0196	External Tank Attachment w/Clevis
	0214	Large Curved External Piece
	0312	Large External Piece
	0468	Large External Piece
	0487	Large External Piece w/Clevis
	0510	Large External Piece
	0524	Large External Piece
	0605	Medium External Piece
	0631	Medium External Piece w/Clevis and Tang
	0635	Forward Motor Casing
	0699	Forward Segment
	0711	Medium External Piece
	5038	Large External Piece w/Clevis
	0539	Large External Piece w/Tang
	5125	Medium External Piece
	5126	Medium External Piece (3)
	5127	Large External/Internal Piece
	5128	Medium External Piece
	5433	Medium Motor Skin Piece

Several pieces from the Orbiter and ET debris contained pyrotechnic devices. The majority of the SRB debris contained pyrotechnics or unburned propellant. The pyrotechnics were either safed or destroyed by Explosive Ordnance Disposal (EOD) personnel. The fragments of the cases were used as physical evidence in the reconstruction process; therefore, a burn plan was developed to remove (burn) the unused propellant without damaging the case material. The unburned propellant was burned off the case without destroying any evidence. Video tapes were made to document the "before" and "after" state of the debris.

F. *Structural Reconstruction and Evaluation*

The National Transportation Safety Board (NTSB) evaluated the recovered debris in an effort to determine the probable failure mode of the Orbiter including the Payload, the External Tank (ET), and each Solid Rocket Booster (SRB). The following is a brief description of the techniques for control and reconstruction of the debris with a probable failure mode for each element. A more detailed explanation is found in Enclosure No. 8, Space Transportation System, Mission 51-L Structural Evaluation Report.

1. *Reconstruction Technique*

Recovered Shuttle debris was returned by ship to the docks at Port Canaveral and screened for material. The debris was loaded onto pallets and trucks for transport to KSC or the Cape Canaveral Air Force Station (CCAFS) where impoundment areas had been established. Access to the impoundment areas was controlled by KSC and Air Force security forces on a 24-hour, 7-day per week basis. The three major impoundment areas were large enough to accommodate almost the full dimensions of the STS subsystems—Orbiter, ET, and SRB's. A separate area was established on the EOD Range for hazardous material. The impoundment area for the SRB's was located in a remote hangar (Hangar "O") near the Eastern Space and Missile Center (ESMC) EOD Range because the pieces of SRB contained unburned and potentially hazardous propellant.

As the debris arrived at the impoundment area, it was unloaded from the trucks with forklifts and transferred to the identification area. In the latter area, the pieces were video taped, photographed, identified by Quality Assurance personnel, and appropriately tagged. Each piece of debris was assigned an identification number based on its time of arrival at the impoundment area, and a chronological record was prepared which included the identification number; description; time and date of arrival; related photograph numbers; date; time; and location (latitude and longitude) of recovery (if known); and the name of the ship that delivered the debris to the docks.

The impoundment areas for the Orbiter and ET were divided into a grid with yellow tape.The pieces of debris were placed in the appropriate squares which corresponded to their original configuration. As the quantity of debris increased, platforms and stanchions were constructed upon which the pieces of debris were placed or secured vertically. Various internal storage tanks from the Orbiter were identified and collected in one location for further examination—see Photographs 1 and 2 for layouts of the Orbiter and ET debris, respectively.

Table 3 lists recovered electronic components such as General Purpose Computers (GPC's) and tape recorders. These components were washed with fresh water and sent to other facilities for evaluation. This report will not include the analysis of those components.

Table 3. Orbiter Components Returned for Analysis

Item	*# Onboard 51-L*	*# Recovered*	*Data Analysis Group*
Main Engine Controllers	3	3	Honeywell Inc., Avionics Div.
Active General Purpose Computers (GPC's) *			
Central Processing Unit (CPU)	5	4	IBM, Avionics Div.
Input/Output Processor (IOP)	5	5	IBM, Avionics Div.
Display Electronics Unit (DEU)	5	4	IBM, Avionics Div.
Operations Recorder	2	2	Marshall Space Flight Center
Modular Auxiliary Data System (MADS) Recorder	1	1	Marshall Space Flight Center
Mass Memory Unit (MMU)	2	2	Marshall Space Flight Center

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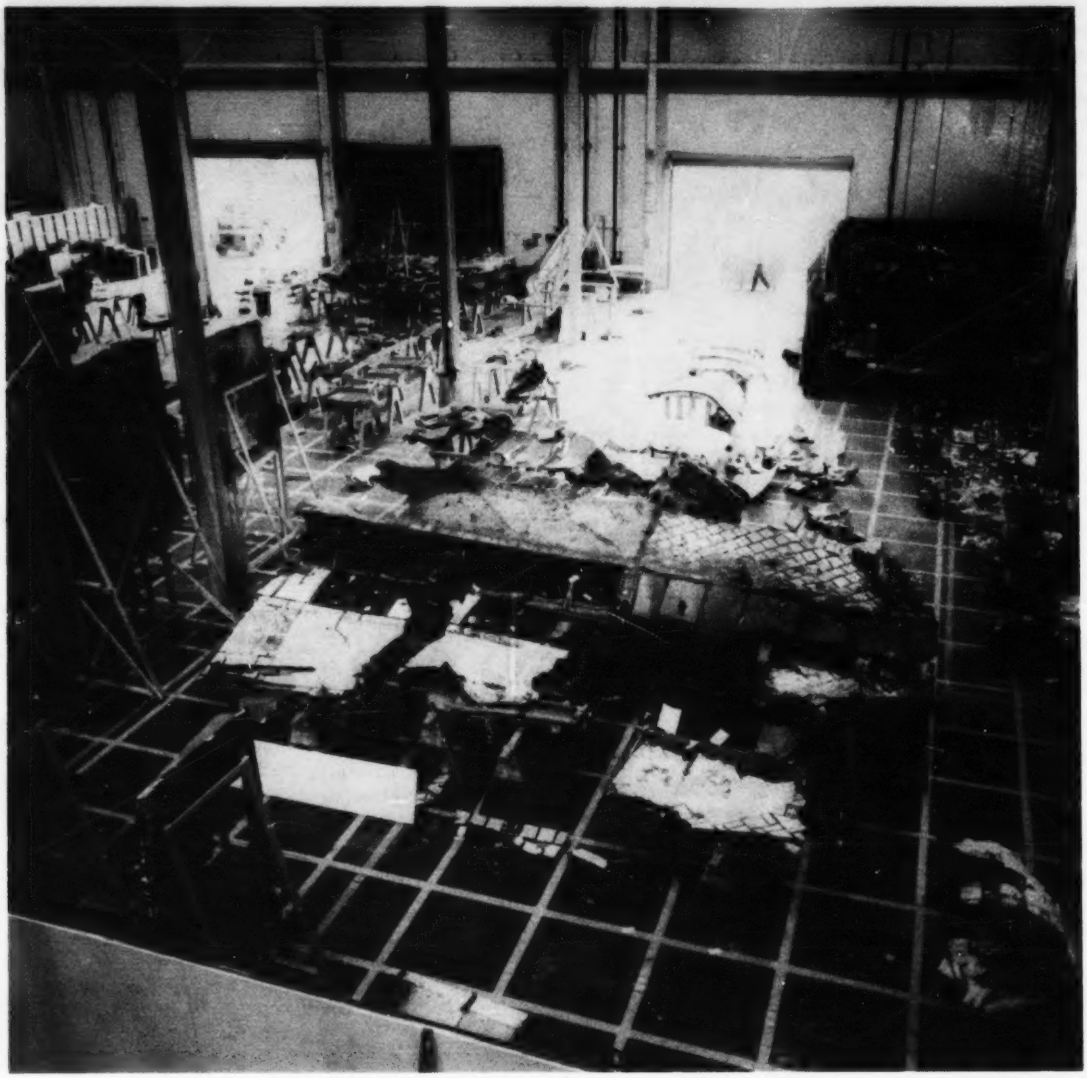
* Does not include spare GPC that was recovered but not analyzed.



Photograph 1. Layout of Orbiter Debris

Photograph 2. Layout of External Tank Debris

Pieces of debris that were removed from the impoundment areas for metallurgical or chemical analysis were accounted for by hand receipt. Video tapes, pertinent photographs, and records of the photographs taken were kept in safes in the impoundment areas.

After transport to the EOD area (Hangar "O"), the pieces of SRB debris were initially evaluated and identified. The pieces containing unburned propellant were then taken to the EOD range where the propellant was burned in accordance with a propellant disposal plan that was developed and tested. The plan provided for safe disposal of the propellant and complete protection of the evidence in the process. Records including video tapes of the propellant burning processes were maintained. Following propellant disposal, the pieces of the SRB's were returned to Hangar "O" for storage and evaluation.

2. *Probable Failure Mode (Orbiter With Payload)*

Insufficient structure was recovered to definitely establish the failure mode of the Orbiter, Challenger. However, the fact that all material failures occurred from overload with no evidence of internal burn damage or exposure to explosive forces indicates that destruction of the Orbiter occurred predominantly from aerodynamic, acceleration, and inertial forces that exceeded design limits.

There is evidence that the right SRB contacted the bottom surface of the outboard section of the right wing which may have contributed to the separation of the right wing from the Orbiter. The evidence includes crush damage on the bottom surface of the right wing and outboard elevon, positive (+ z) bending and fractures in sections of the right elevon and inboard structure of the right wing, and high inertial loading on the right main landing gear and on the IUS's right spreader beam. The Orbiter axes are shown in Figure 4. Further, the proliferation of alpha aluminum oxide residue from molten SRB propellant on various surfaces on the right side of the Orbiter in conjunction with the approximate geometric relationship of the right wing to the inboard circumference of the right SRB during normal flight indicates that as the SRB moved upward (+ z) into contact with the right wing, and as the wing separated from the Orbiter, the right side of the Orbiter was sprayed by hot gases exhausting from the hole in the inboard circumference of the SRB. It is possible that this contact between the right SRB and the Orbiter assisted in separating the Orbiter from the ET in a rapid counter-clockwise rolling movement that exposed the Orbiter to destructive aerodynamic and inertial forces.

The structural evaluation established clearly that the crew module, including most of its outer shell, remained essentially intact until impact with the water and that the module was fragmented extensively from extreme overload and inertial forces associated with water impact. The structural deformations and fragmentations indicate that the module struck the water in a slight nose down and steep left bank attitude.

Evaluation of the SSME's indicated extensive internal thermal damage as a consequence of oxygen-rich operation that resulted from depletion of the hydrogen fuel supply. The positions of various engine valves indicate the engine control system for No. 1 engine was correcting for the loss of the hydrogen fuel supply; the No. 2 engine was in the shutdown phase; and the No. 3 engine was in mainstage operation when hydraulic and pneumatic power sources were lost. There was no evidence to indicate that SSME or MPS malfunctions or failures contributed to the destruction of the Orbiter.

There was no evidence to indicate that the IUS contributed to premature structural failure of the Orbiter.

3. *Probable Failure Mode (External Tank)*

Insufficient structure was recovered to positively establish the failure mode of the ET. However, the structure recovered indicates that the LH_2 tank probably failed from external forces and thermal damage from the fire that erupted from the inboard circumference of the right SRB about 58 seconds after liftoff. The fire probably impinged on the ET near the lower attachment fittings for the right SRB and separated one or more of the three lower attachment fittings. The separation of the fitting(s) allowed the right SRB to twist about its single upper ET attachment fitting to the extent that the frustum joint penetrated the intertank near the 70-degree and X_T1000 location. The penetration of the intertank by the right SRB frustum probably forced the intertank structure into the LO_2 tank which permitted escape and vaporization of the LO_2. Figure 5 shows the External Tank and reference axes.

The separation of the lower attachment fittings on the right SRB indicates that breach of the LH_2 tank preceded compromise of the LO_2 tank. The LH_2 tank probably failed from thermal damage near the welded seam that attaches the aft ellipsoidal dome to the tank cylinder. The thermally-weakened seam probably failed circumferentially under the weight of the LH_2 as magnified by longitudinal acceleration forces.

4. *Probable Failure Mode (Solid Rocket Booster)*

As of May 1, 1986, 42 pieces of the two SRB's had been recovered, including 2 pieces of the right SRB (sidescan sonar Contacts Nos. 131 and 712) that identified the approximate dimensions of the hole burned through the side of the SRB near the lower field joint. Since these two pieces of the right SRB contained the physical evidence pertinent to the failure of the right SRB that initiated the accident sequence, further search and recovery efforts for pieces of SRB were discontinued as of the above date. The evaluation of Contact Nos. 131 and 712 is contained in Volume 4, Enclosure 9, of this report.

The right frustum sustained more nose damage than the left frustum. There was evident and unique damage to the base of the frustum at the 240- to 255-degree circumferential location (reference Figure 6). Chemical analyses of deposits in the damaged area established the presence of polyurethane of the type used for outer insulation of the ET intertank. Also, indentations in the damaged area were spaced about 5 inches apart which corresponds to the spacing between the vertical stringers in the ET intertank.

None of the 19 pieces of the right SRM or the pieces of the left SRM evaluated in this report provided indication of any structural failures that may have occurred before the SRM's were destroyed by detonation of the LSC's attached to the casings along the system tunnel of each SRM.

VI. Findings and Conclusions

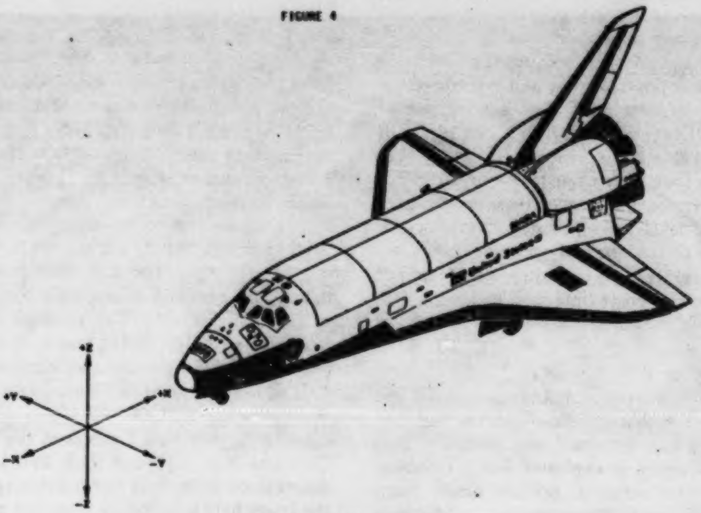
A. *Physical Evidence Versus Fault Tree Analyses Findings*

The Search, Recovery, and Reconstruction Team compared the physical evidence obtained from the Mission 51-L Shuttle recovery debris with the conclusion of the Accident Analysis Team's Fault Tree. The Fault Tree was annotated with symbols indicating those areas where the physical evidence supports or contradicts the analytical findings. These are shown on Figures 7, 8, and 9 with a brief explanation following.

1. No physical evidence exists or the physical evidence available is *insufficient to support or contradict* the following nodes on the fault tree analyses.

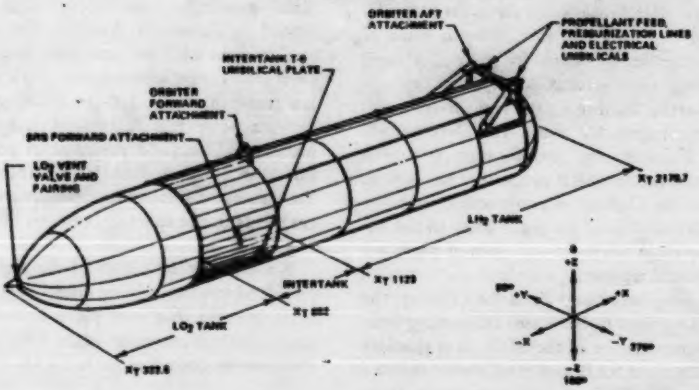
Node	*Fault Tree*	*Description*
3	Improbable	Orbiter
6	Improbable	External Tank (ET)
8	Improbable	ET Damage at Liftoff
10	Improbable	ET Structural Flaw
14	Improbable	SRB Premature LSC Detonation
15	Improbable	ET Damage at Liftoff Caused by Facility
16	Improbable	ET Damage at Liftoff Caused by Pad Debris
17	Improbable	ET Damage at Liftoff Caused by Other Circumstances
18	Improbable	ET Structural Flaw Undetected at Fabrication
19	Improbable	ET Structural Overload Caused by TPS Loss

FIGURE 4



ORBITER AND REFERENCE AXES

FIGURE 5


ORBITER AFT ATTACHMENT
PROPELLANT FEED, PRESSURIZATION LINES AND ELECTRICAL UMBILICALS
INTERTANK T-0 UMBILICAL PLATE
ORBITER FORWARD ATTACHMENT
SRB FORWARD ATTACHMENT
LO2 VENT VALVE AND FAIRING
XT 2170.7
LH2 TANK
INTERTANK
XT 1129
XT 852
LO2 TANK
XT 322.5
0
+Z
90° +Y
+X
-X
-Y 270°
-Z
180°

External Tank & Reference Axes

SRB COORDINATE SYSTEM

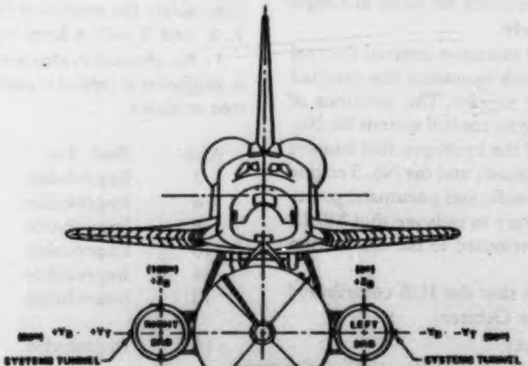

(180°)
+ZB
(90°) +YB +YT
RIGHT SRB
SYSTEMS TUNNEL
-ZB
(0°)
EXTERNAL TANK
(0°)
+ZB
LEFT SRB
-YB -YT (90°)
SYSTEMS TUNNEL
-ZB
(180°)
LOOKING AFT

Figure 6

20	Possible	ET/SRB Structural Overload Caused by Liftoff or Flight Loads
22	Improbable	SRM Pressure Integrity Violation Caused by Case Membrane Anomaly

The events or forces preceding the recovery of the physical evidence, such as aerodynamic breakup, nine-mile free fall, water impact, winds, currents, all combine to obscure or shield the possible findings and conclusions.

2. Physical evidence (fractured surfaces) indicated structural overload. No signs of stress corrosion, fatigue, or hydrogen embrittlement was found. This physical evidence *supports* the following nodes on the fault tree analyses.

Node	*Fault Tree*	*Description*
1	Probable	Total Vehicle Structural Breakup
2	Probable	ET Structural Breakup

The types and quantities of deformation and fractures seen on the recovered debris are consistent with the forces involved in an aerodynamic breakup and water impact. Physical evidence from recovered structures does not indicate structural overload was a cause but rather a result of some other malfunction. This conclusion is based on approximately 20% recovery of the ET. (See Photograph 2, Layout of ET Debris.)

3. Physical evidence (fractured surfaces) indicated structural overload. No signs of stress corrosion, fatigue, or hydrogen embrittlement were found. This physical evidence *supports* the following nodes on the fault tree analyses.

Node	*Fault Tree*	*Description*
11	Improbable	ET Structural Overload
12	Improbable	SRB Structural Overload

The ET intertank failed due to structural overload caused by contact with the right hand SRB. This in turn caused the LO_2 tank to fail.

The ET LO_2 tank failed due to structural overload caused by internal overpressurization. The ET LH_2 tank failed due to structural overload caused by external overloads rather than from an internal overpressurization.

The SRB's failed due to structural overload. All fractured surfaces exhibited either the characteristic herringbone or chevron markings of rapid tensile overload, a complete bending failure due to overload, or a jet-separation fracture due to the detonation of the linear-shape charges (LSC's).

The above findings are based on physical evidence, *however, observations, video tape, and film show the tank structurally failing after other abnormal RH SRB events*, and the SRB's continuing in erratic powered flight until the Command Destruct signal was sent by the Range Safety Officer. (Reference Photograph 3 for SRB Fracture Surface.)

4. The physical evidence indicated the SSME's (main engines) were operating until Orbiter breakup. This *supports* the Fault Tree analysis.

Node	*Fault Tree*	*Description*
4	Improbable	Space Shuttle Main Engines

Valve positions on the three main engines were examined to determine what phase of operation each engine was experiencing. Several valves were damaged by impact such that their position was invalid. Two engines were found to be in main stage (full operation) and one in a shutdown phase when hydrogen depletion occurred. Damage to the engines was consistent with oxygen-rich operation and loads associated with water impact. (Reference Photograph 4, SSME as Recovered.)

5. The physical evidence indicated the external tank (ET) LSC's did not have a premature detonation. This *supports* the Fault Tree analyses.

Node	*Fault Tree*	*Description*
9	Improbable	ET Premature LSC Detonation

The linear-shaped charges from both the LO_2 and LH_2 tanks were recovered; the charges had not detonated. (Reference Photographs 5 and 6, Undetonated Linear-Shaped Charges.)

6. The physical evidence of the Inertial Upper Stage (IUS) recovered components shows no evidence of fire, explosion, or any premature element separation. This *supports* the Fault Tree.

Node	*Fault Tree*	*Description*
5	Improbable	Cargo—Inertial Upper Stage

7. The physical evidence of the recovered IUS/TDRS/ASE components indicates a structural breakup not caused by premature ignition, explosion, or fire. This *supports* the Fault Tree analyses.

Node	*Fault Tree*	*Description*
23	Improbable	IUS Premature Ignition
24	Improbable	Explosion/Fire in Payload Bay
26	Improbable	IUS Premature Ignition Caused by Electrostatic Discharge
27	Improbable	IUS Premature Ignition Caused by Inadvertent Ignition Command
28	Improbable	IUS Premature Ignition Caused by Auto Ignition
29	Improbable	IUS Explosion/Fire in Payload Bay Caused by RCS Failure
30	Improbable	IUS Explosion/Fire in Payload Bay Caused by Battery Failure
31	Improbable	IUS Explosion/Fire in Payload Bay Caused by Electrically Induced Fire
32	Improbable	IUS Explosion/Fire in Payload Bay Caused by RF Radiation
33	Improbable	IUS Explosion/Fire in Payload Bay Caused by SRM Burning

The debris from the payload was found to be shattered into many small fragments. There was no evidence of burning or fire on the recovered pieces. Unburned propellant fragments were among the pieces found. (Reference Photograph 7, Unburned or Unscorched Debris from Payload Bay.)

8. The physical evidence of the recovered IUS ASE indicates damage consistent with the IUS remaining attached to the Orbiter mounting until Orbiter structural breakup. This *supports* the Fault Tree analyses.

Node	*Fault Tree*	*Description*
25	Improbable	IUS Element Separation

The two aft trunnion spreader beams which support the IUS in the Orbiter payload bay were recovered. Both beams contained a permanent deformation indicative of a large $+z$ acceleration while the IUS was still attached. This is considered evidence the structural breakup of the Orbiter began while the IUS was still being supported by the ASE. (Reference Photograph 8, Bent IUS Beam.)

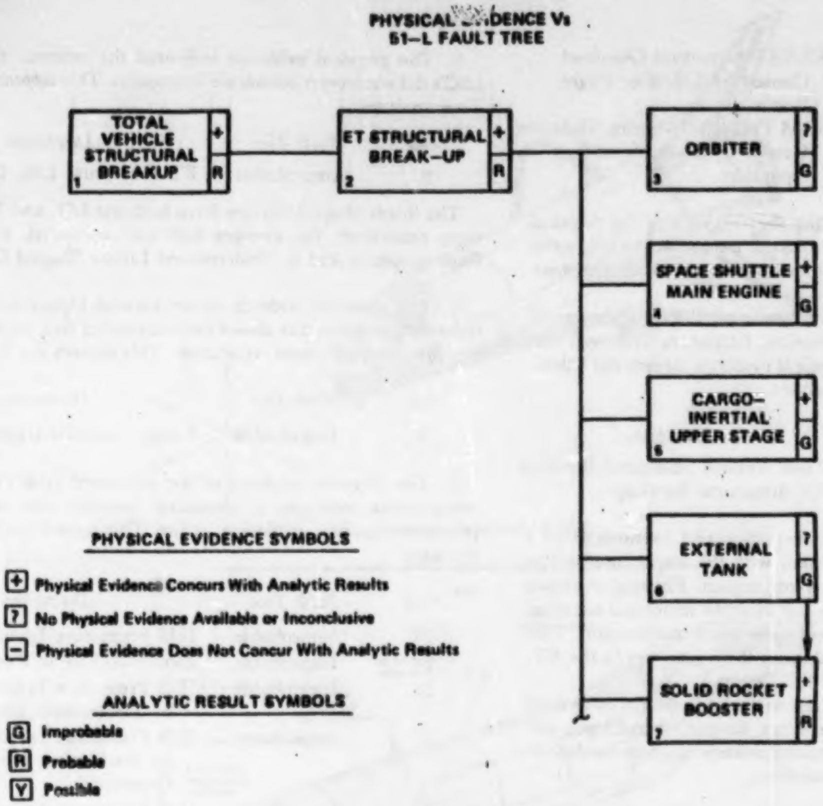

PHYSICAL EVIDENCE Vs
51–L FAULT TREE
TOTAL VEHICLE STRUCTURAL BREAKUP
1
+
R
ET STRUCTURAL BREAK–UP
2
+
R
ORBITER
3
?
G
SPACE SHUTTLE MAIN ENGINE
4
+
G
CARGO–INERTIAL UPPER STAGE
5
+
G
EXTERNAL TANK
6
?
G
SOLID ROCKET BOOSTER
7
+
R
PHYSICAL EVIDENCE SYMBOLS
+ Physical Evidence Concurs With Analytic Results
? No Physical Evidence Available or Inconclusive
– Physical Evidence Does Not Concur With Analytic Results
ANALYTIC RESULT SYMBOLS
G Improbable
R Probable
Y Possible

FIGURE 7

EGG/RHB–13

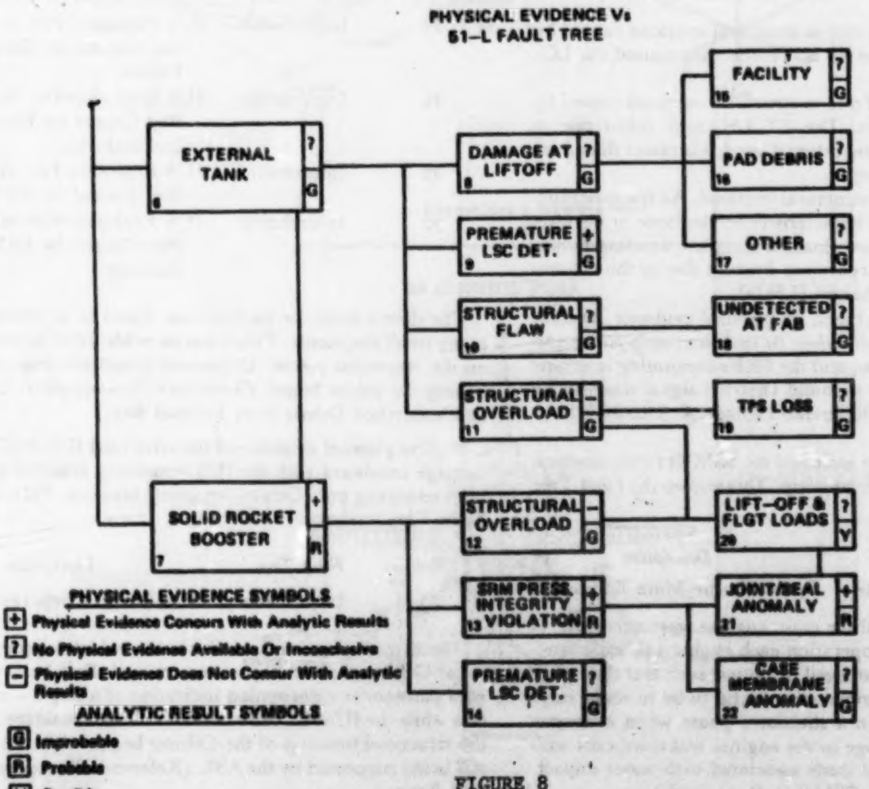
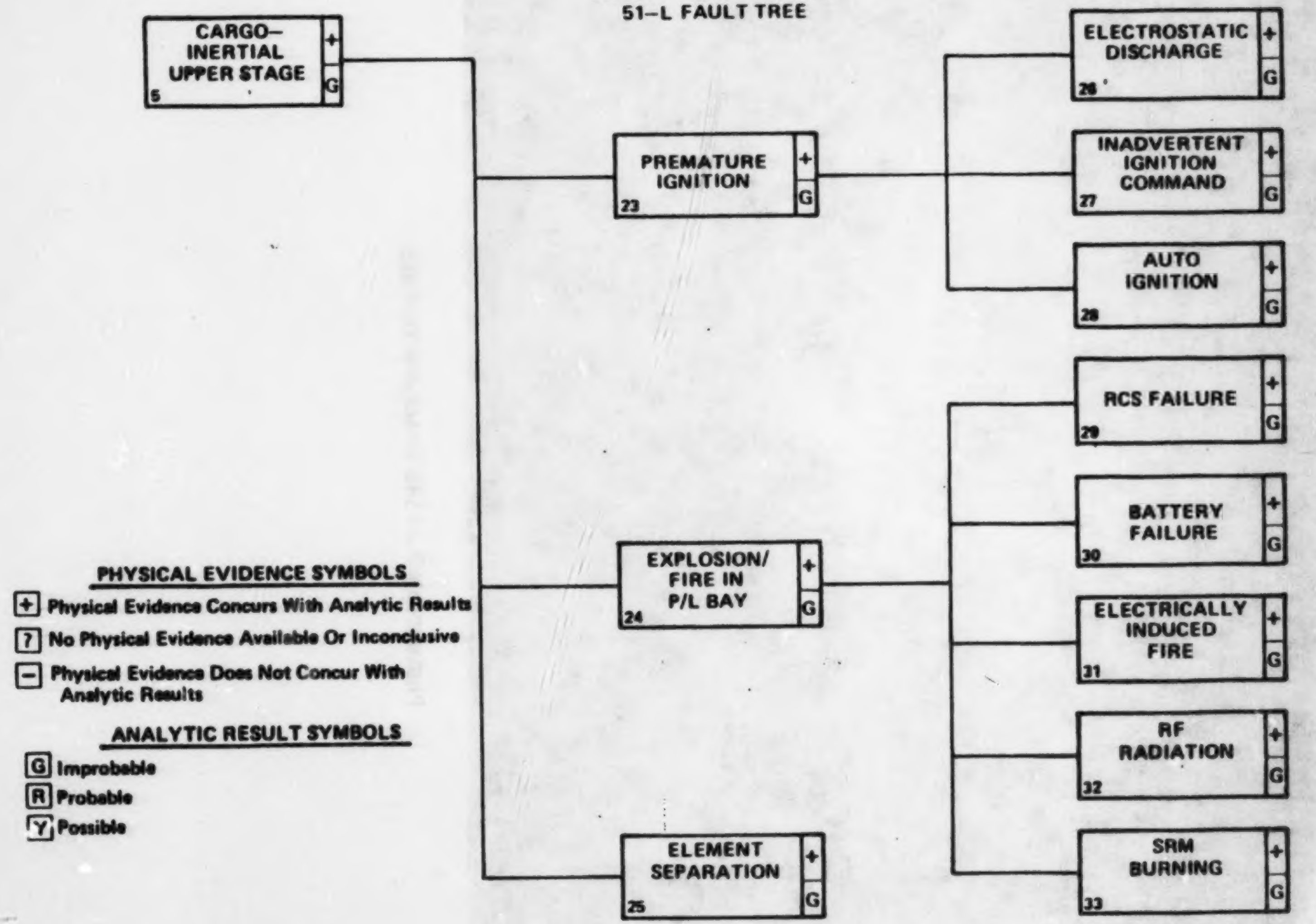

PHYSICAL EVIDENCE Vs
51–L FAULT TREE
EXTERNAL TANK
6
?
G
SOLID ROCKET BOOSTER
7
+
R
DAMAGE AT LIFTOFF
8
?
G
PREMATURE LSC DET.
9
+
G
STRUCTURAL FLAW
10
?
G
STRUCTURAL OVERLOAD
11
–
G
STRUCTURAL OVERLOAD
12
–
G
SRM PRESS. INTEGRITY VIOLATION
13
+
R
PREMATURE LSC DET.
14
+
G
FACILITY
15
?
G
PAD DEBRIS
16
?
G
OTHER
17
?
G
UNDETECTED AT FAB
18
?
G
TPS LOSS
19
?
G
LIFT–OFF & FLGT LOADS
20
?
Y
JOINT/SEAL ANOMALY
21
+
R
CASE MEMBRANE ANOMALY
22
?
G
PHYSICAL EVIDENCE SYMBOLS
+ Physical Evidence Concurs With Analytic Results
? No Physical Evidence Available Or Inconclusive
– Physical Evidence Does Not Concur With Analytic Results
ANALYTIC RESULT SYMBOLS
G Improbable
R Probable
Y Possible

FIGURE 8

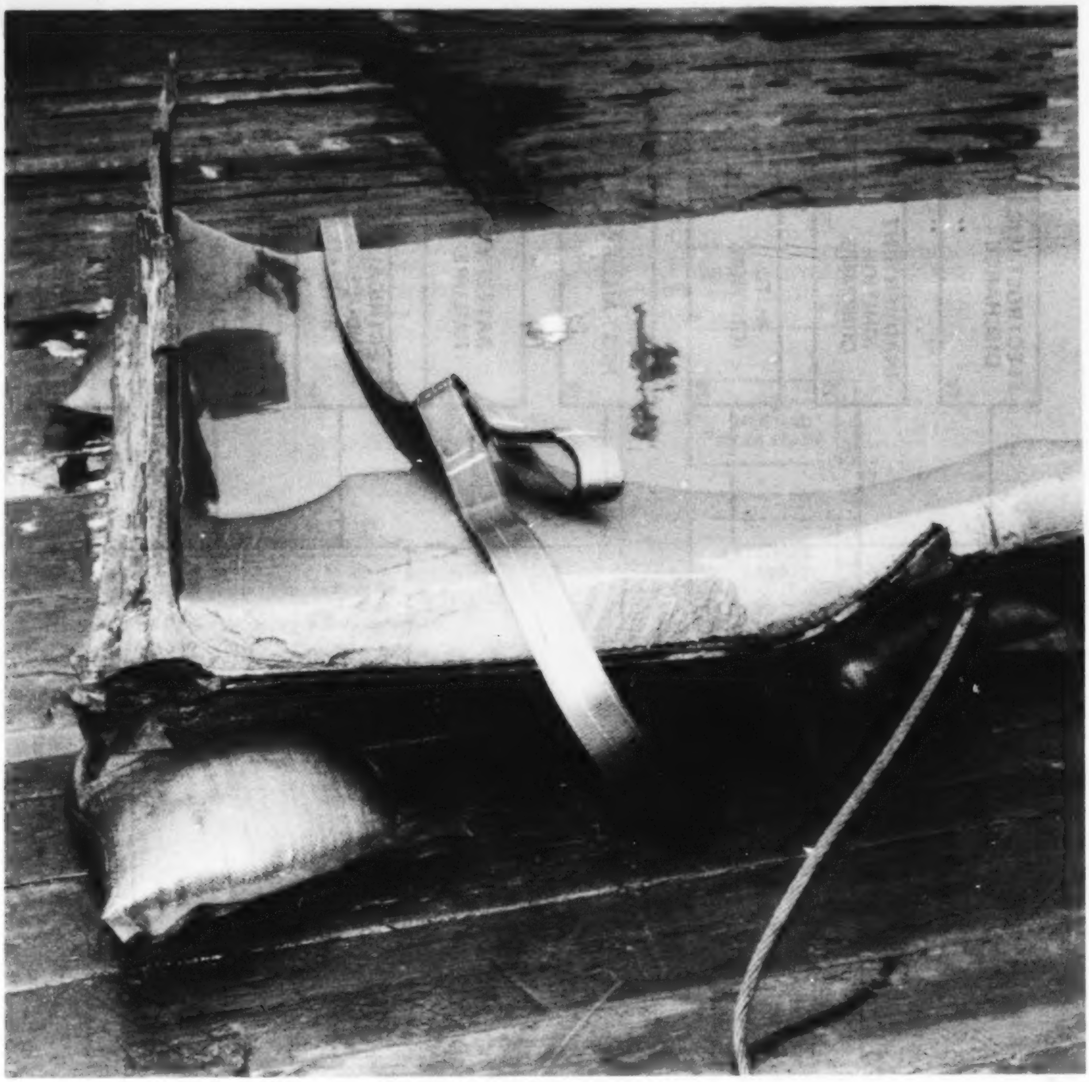
EGG/RHB–13A

PHYSI. EVIDENCE Vs
51–L FAULT TREE

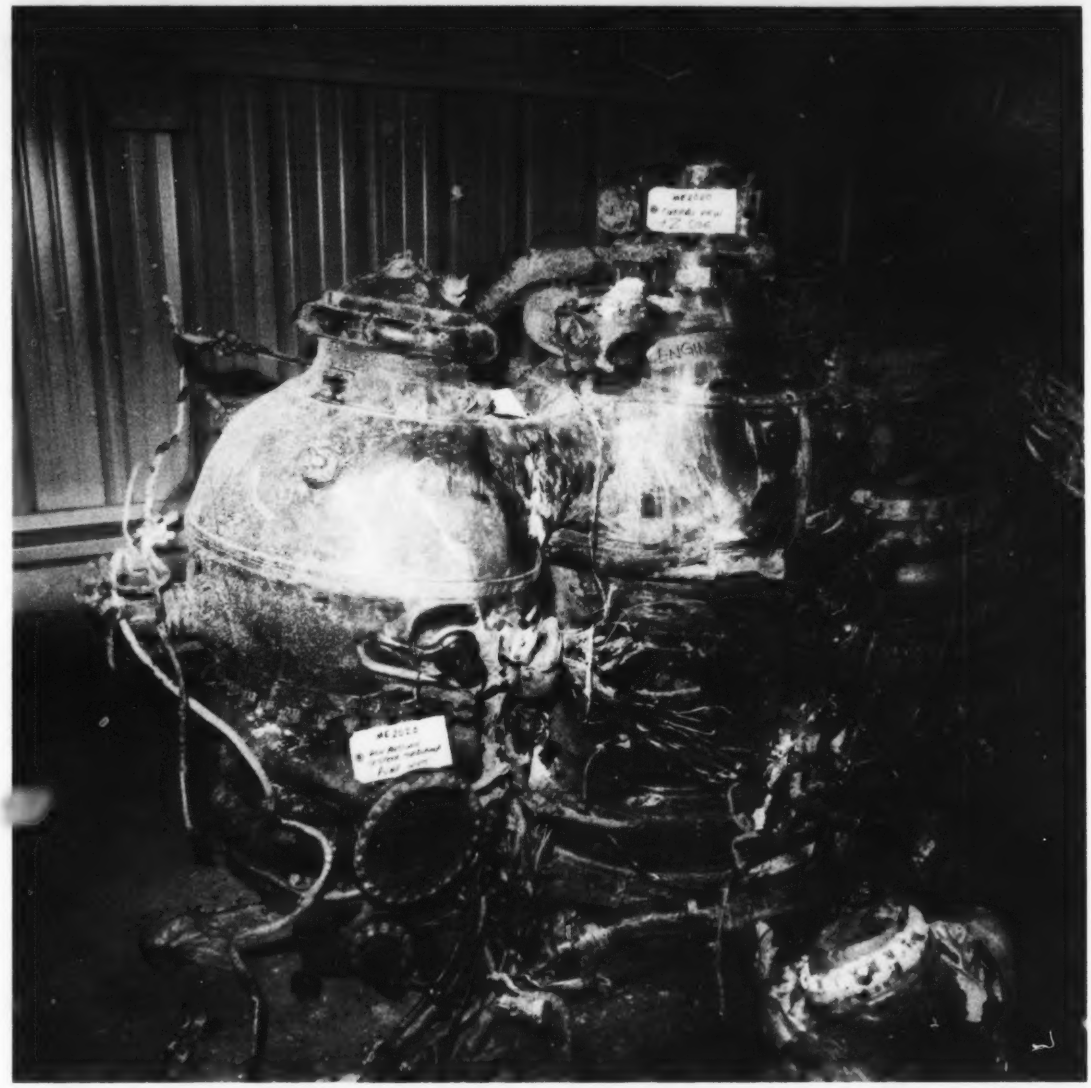

CARGO–
INERTIAL
UPPER STAGE
5
+
G
PREMATURE
IGNITION
23
+
G
EXPLOSION/
FIRE IN
P/L BAY
24
+
G
ELEMENT
SEPARATION
25
+
G
ELECTROSTATIC
DISCHARGE
26
+
G
INADVERTENT
IGNITION
COMMAND
27
+
G
AUTO
IGNITION
28
+
G
RCS FAILURE
29
+
G
BATTERY
FAILURE
30
+
G
ELECTRICALLY
INDUCED
FIRE
31
+
G
RF
RADIATION
32
+
G
SRM
BURNING
33
+
G
PHYSICAL EVIDENCE SYMBOLS
+ Physical Evidence Concurs With Analytic Results
? No Physical Evidence Available Or Inconclusive
− Physical Evidence Does Not Concur With Analytic Results
ANALYTIC RESULT SYMBOLS
G Improbable
R Probable
Y Possible

EGG/MIB 138

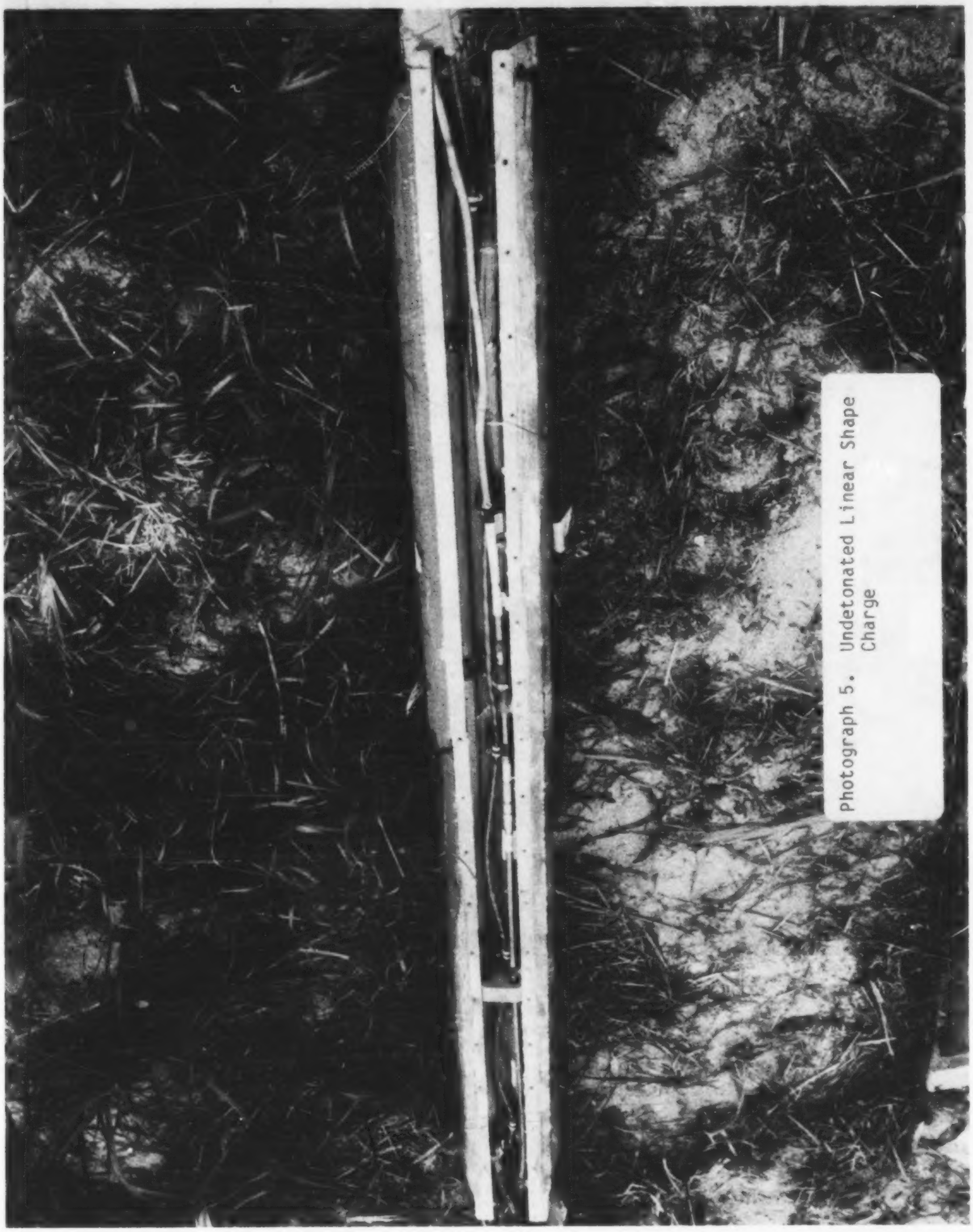
FIGURE 9



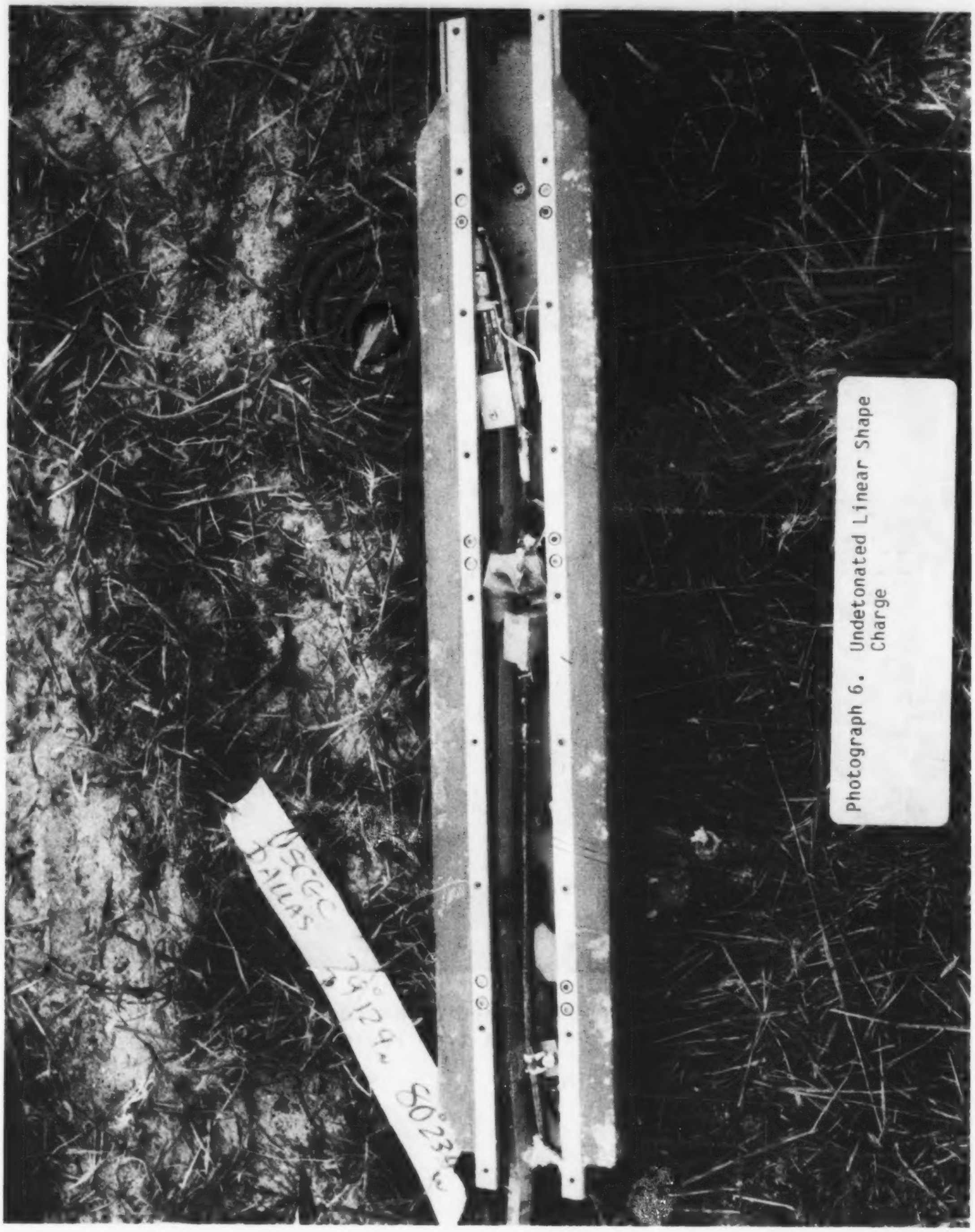
Photograph 3. SRB Fracture Surface



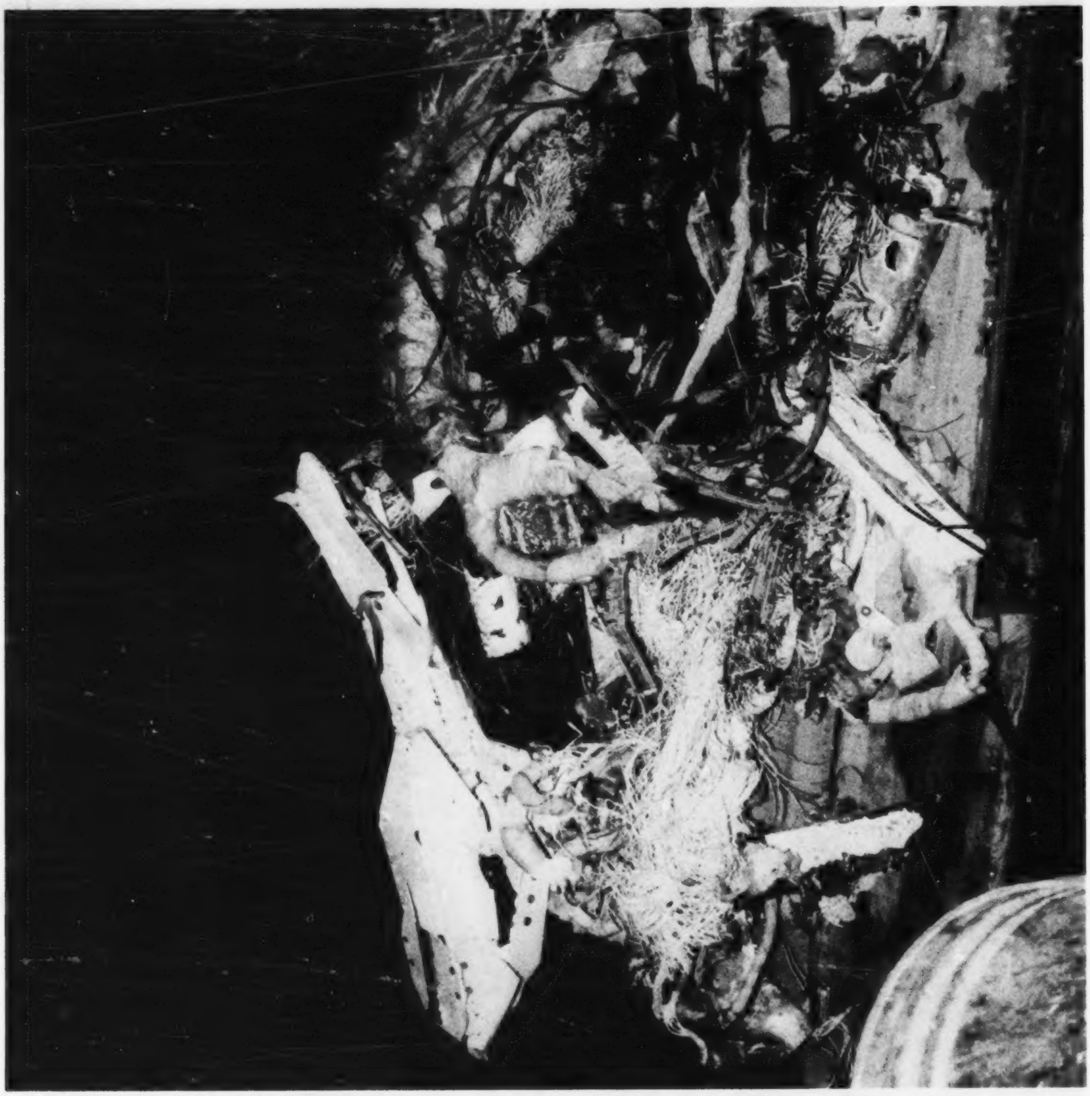
Photograph 4. SSME as Recovered



Photograph 5. Undetonated Linear Shape Charge


USCGC
DALLAS
29°129
80°23

Photograph 6. Undetonated Linear Shape Charge



Photograph 7. Unburned or Unscorched Debris from Payload Bay

Photograph 8. Bent IUS Beam

9. The physical evidence of portions of both sides of the right-hand SRB aft field joint indicate a burn through in the 270° to 360° quadrant. This *supports* the Fault Tree Analysis.

Node	*Fault Tree*	*Description*
7	Probable	Solid Rocket Booster (SRB)
13	Probable	SRM Pressure Integrity Violation
21	Probable	SRM Pressure Integrity Violation Joint/Seal

The portions of the RH SRB aft field joint indicate a hole caused by a violation of pressure integrity of the joint. The portions, when aligned, indicate the hole to be consistent with area where smoke was observed during the lift off sequence by two cameras. Photographs 9 and 10 show the physical evidence of the aft center segment with burn through hole. Photograph 11 shows the hole as mocked up on another RH SRB aft field joint. These two portions of RH SRB were recovered Contacts #131 and #712

NOTE: Sections B and C are exact duplicates of the findings and conclusions found in Enclosure 8, National Transportation Safety Board's Structural, Reconstruction and Evaluation Report.

B. *Findings.*

1. About 30 percent of the Orbiter's total structure was recovered including about 75 percent of the crew module and surrounding forward fuselage shell structure.

2. About 20 percent of the ET was recovered; the structure was predominantly from the intertank and LH_2 tank of the ET.

3. All fractures examined on the STS structure had failed from overload forces; there was no evidence of fatigue, stress corrosion cracking, or manufacturing defect.

4. The lower structure of the LH_2 tank portion of the ET contained a minor weld imperfection; the imperfection did not contribute to the failure of the LH_2 tank.

5. There was no evidence of internal fire or explosion in the Orbiter preceding its disintegration.

6. The Orbiter was destroyed predominantly by high acceleration loads, high inertial load, and adverse aerodynamic forces.

7. Following separation of one or more of its lower attachment fittings to the ET, the right SRB struck the lower outboard portion of the Orbiter's right wing contributing to the separation of the wing from the Orbiter.

8. The aft right side of the Orbiter was burned by hot propellant gases exhausted probably from the hole in the inboard circumference of the right SRB.

9. The SSME's were functioning properly until the LH_2 supply was terminated by the failure of the LH_2 tank and/or tank connections to the Orbiter.

10. There was no evidence of malfunction or failure of the ASE/IUS/TDRS package in the Orbiter's payload bay before the right SRB forcefully contacted the Orbiter's right wing.

11. The crew module separated from the Orbiter at frame 582; the aft pressure bulkhead (576) remained with the crew module.

12. The crew module and surrounding forward fuselage shell structure forward to bulkhead 378 descended to the surface of the Atlantic Ocean essentially intact; these structures probably struck the surface in a nose down and steep left bank attitude.

13. The crew module and forward fuselage structure disintegrated from high deceleration and inertial forces associated with water impact.

14. The base of the right SRB frustum penetrated the intertank structure of the ET following release of one or more of the SRB's lower attachment fittings to the ET.

15. The LO_2 tank in the ET probably was breached by intertank structure which permitted LO_2 to escape and vaporize in the relatively warm atmosphere.

16. Fragmented LO_2 tank structure may have been burned by vaporized LO_2 following failure of the LO_2 tank.

17. The LH_2 tank in the ET probably failed from external forces and thermal damage near the aft ellipsoidal dome.

18. The pieces of SRB evaluated in this report were unremarkable; all fractures were from overload or from detonation of LSC's.

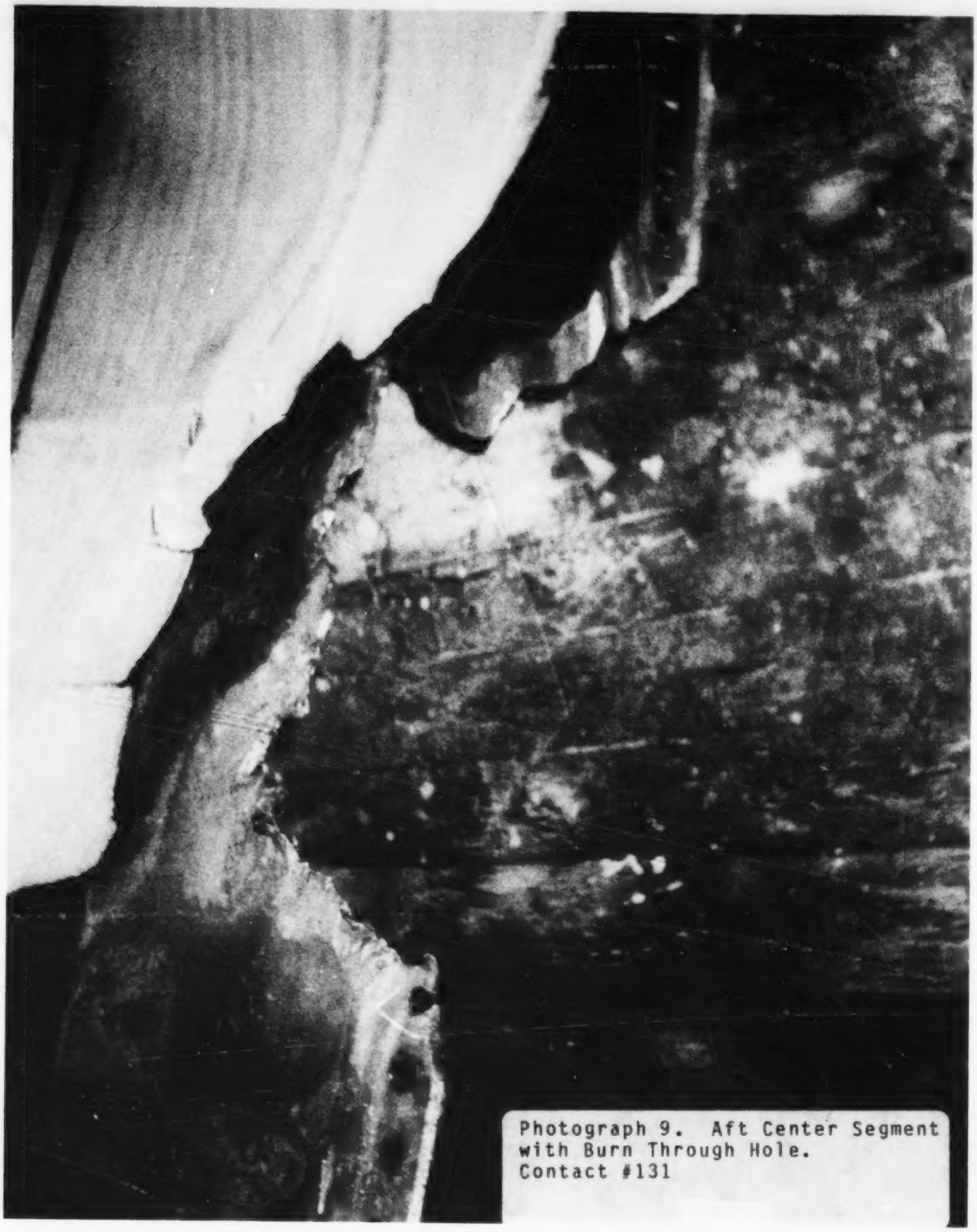
C. *Conclusions*

1. There is no evidence that structural failures in either the Orbiter or its payload package preceded the destruction of STS 51-L.

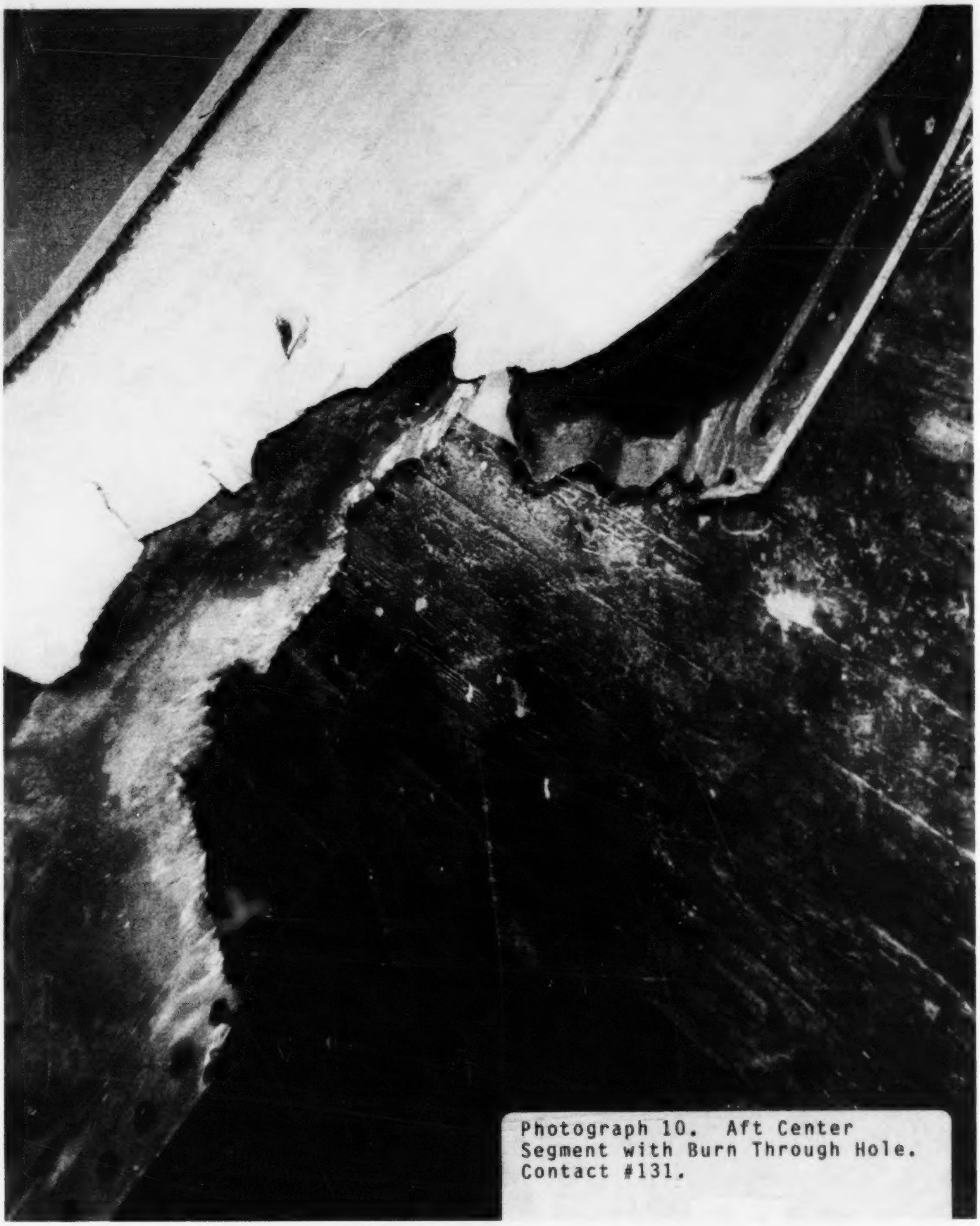
2. The Orbiter's MPS and SSME's functioned properly and did not contribute to the loss of STS 51-L.

3. The Orbiter's crew module was essentially intact until it struck the surface of the Atlantic Ocean; the crew module was disintegrated by water impact forces.

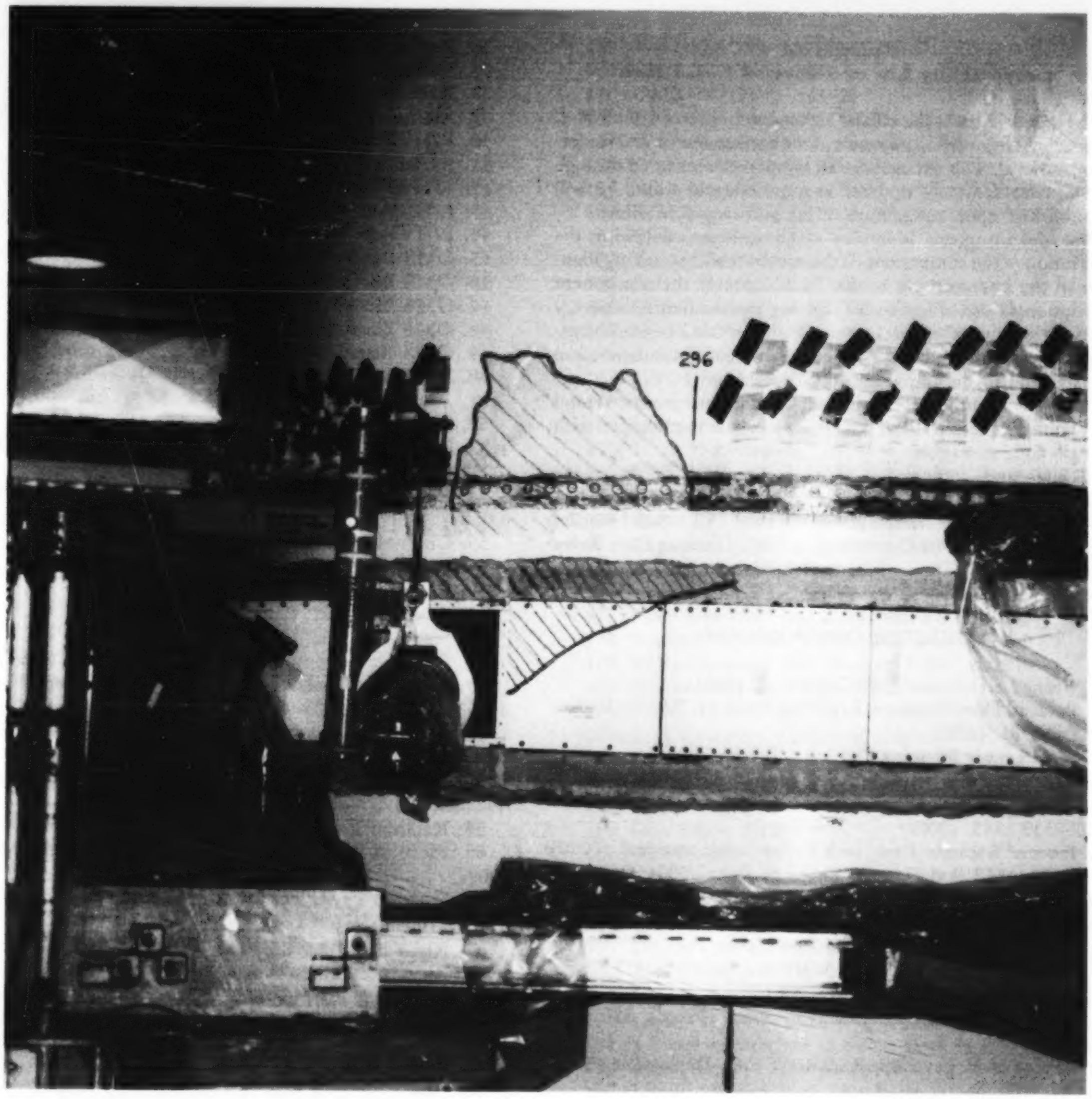
4. The ET probably failed from thermal and structural damage near the base of its LH_2 tank and from overpressurization of its LO_2 tank following partial separation of the right SRB from the ET.



Photograph 9. Aft Center Segment with Burn Through Hole. Contact #131



Photograph 10. Aft Center Segment with Burn Through Hole. Contact #131.



Photograph 11. Mock-up of Hole
on Right Hand SRB Aft Field Joint

Appendix A
Accountability List of Recovered 51-L Debris

The attached list is the official accountability record of all 51-L components recovered as a result of the surface search and underwater retrieval. This list includes all components retrieved through May 6, 1986. It will be updated as required, and a final list will be published upon completion of the recovery operation.

The alpha/numeric identifier in parentheses, following the description of the component, is the accountability tracking identifier in the impound log books. In addition to the component description recorded in this list, the log books identify recovery location (longitude/latitude), retrieval ship, film data (each component was photographed), any available serial/part number, and grid location in the impound area.

Many small components were identified to a major system and put together in a container. The container was then tagged with a single code identifier.

All hazardous components which are stored at the Explosive Ordnance Disposal (EOD) impound area are included in this list.

This list includes Orbiter, External Tank (ET), Solid Rocket Booster (SRB), Inertial Upper Stage (IUS), Tracking Data Relay Satellite (TDRS), Thermal Protection System (Tile), and Crew Module components

ORBITER COMPONENTS

1. Front Left Corner L/H OMS Pod. (0001)
2. Payload Door Segment, L/H End Panel #1, X0750. Radiation Panel #1. (0003)
3. R/H Lower Forward Fuselage. X0262. (0004)
4. Mid-Body Lower Skin Bay 7, Bay 8, L/H Side. (0006)
5. Wing Lower Skin, B91360010-1 Strut Brace B91860530-1343. (0009)
6. Piece of Radiator Panel with Roller Guide attached. (0010)
7. R/H OMS Pod Skin Panel, FRSI Panel. (0011)
8. Piece of Dome Heat Shield Engine #3. (0012)
9. Honeycomb & FRSI Upper Wing Skin. (0013)
10. Honeycomb & FRSI L/H Pod Upper Forward. (0014)
11. Honeycomb & "A" FRSI, V070-396376-072. CH3 67, remaining OCN number unknown. (0015)
12. Piece of Honeycomb Radiator Panel (Fixed), 31" × 18". (0016)
13. Piece of Honeycomb Radiator Panel, Deployable Piece. 34" × 27". (0017)
14. Elevon Leading Edge Carrier Panel, V070-194127-004. (0018)
15. R/H Inboard Elevon Lower Skin. (0019)
16. LO$_2$, LO$_2$ Fill Drain/Centaur, 8-031427-11. Read SNOH-line. (0020)
17. Piece of Radiator Panel. (0021)
18. R/H Main Landing Gear Door-Skin attached is 1 piece of tile V070-A1036-39, OCN 008218. (0022)
19. Radiator Panel Aft. (0023)
20. Radiator Panel. (0024)
21. Radiator Panel. (0025)
22. Radiator Panel. (0026)
23. Radiator Panel. (0027)
24. Radiator Panel. (0028)
25. Radiator Panel. (0029)
26. Radiator Panel. (0030)
27. Radiator Panel. (0031)
28. Engine Dome Heat Shield. (0032)
29. Outboard Sidewall Main Landing Gear Wheel Well. (0033)
30. Body Flap leading edge lower surface. (0034)
31. Radiator Panel. (0035)
32. R/H OMS Pod Outboard Aft. (0036)
33. Elevon Trailing Edge. (0037)
34. L/H Chine Section. (0038)
35. Lower Mid Fuselage C/L. (0039)
36. Radiator Panel. (0040)
37. Radiator Panel. (0041)
38. Radiator Panel. (0042)
39. Aluminum H/C Panel, suspect Wing Skin. (0043)
40. R/H OMS Blanket Skin. (0044)
41. R/H OMS Blanket Skin Forward. (0045)
42. R/H OMS Blanket Skin. (0046)
43. L/H OMS Blanket Skin. (0047)
44. L/H OMS Blanket Skin. (0048)
45. OMS Blanket Skin. (0049)
46. OMS Blanket Skin. (0050)
47. OMS Blanket Skin. (0051)
48. OMS Blanket Skin. (0052)
49. OMS Blanket Skin. (0053)
50. Blanket, either OMS/PLB. (0054)
51. Blanket. (0055)
52. Blanket. (0056)
53. Payload Retention Protective Cover Devices with Velcro. (0057)
54. Suspect IUS/TDRS Graphite Aluminum Honeycomb. (0058)
55. Charred Metallic Mad Strip. (0063)
56. Insulated Hydraulic Line. (0068)
57. Radiator Panel. (0088)
58. Radiator Panel. (0089)
59. Radiator Panel. (0090)
60. Radiator Piece approximately 4½" × 2½". (0091)
61. Black Box Signal Conditioner, S/N 00006 Dated Manufact. 11/17/80/MC250-0001-0090. (0093)
62. APU Coolant and Water Tank, P/N V070-465510-002, S/N E57596. (0094)
63. Ammonia Tank/Manufact. P/N 74716066-3, PSN 4425064-903 S/N 10. (0095)
64. Radiator Panel with Arm and Swivel Intact. (0096)
65. Piece of Radiator Panel with Forward Latch Attached. (0097)
66. Forward Piece, location was directly below and aft of the FRCS. (0098)
67. Right Hand Aft Sidewall. (0099)
68. Base Heat Shield Bulkhead at the "Y" between SSME 2 & 3. (1516 Bulkhead). (0100)
69. Base Heat Shield Bulkhead from the lower middle of Engine 3 Outboard (0101)
70. End of Radiator Panel with Latch Roller. (0102)
71. L/H Side Piece just Forward of Body Flap Area. (0103)
72. R/H Lower Skin, approximately area of beginning of body wing leading edge. (0104)
73. L/H OMS Pod FRSI & Tile Area. (0105)
74. Flash Evaporator Exhaust Duct. (0106)
75. Flash Evaporator Exhaust Duct. (0107)
76. OMS Pod piece to Aft of Forward of Pod. (0108)
77. Cover at Mid-Body Latch Area. P/N V070-3646-007, OCN B95921. (0109)
78. Cover at Mid-Body Latch Area. P/N V070-364323-024, OCN C25106. (0110)
79. Mid-Body Radiator Panel, approximately 3'0" × 4'0". (0111)
80. Mid-Body Blanket. (0112)
81. R/H Rudder Speed Brake, P/N 170D441400-1, S/N: 1 (Fairchild). (0113)
82. L/H Rudder Speed Brake, P/N 170D441300-1, S/N: 1 (Fairchild). (0114)
83. L/H Payload Bay Door—Forward R/H Corner. (0115)
84. Payload Bay Door Piece, approximately 2'0" × 8'0". (0116)
85. Payload Bay Door Piece, approximately 2'0" × 3'0". (0117)
86. Payload Bay Door Piece (R/H), approximately 1' × 2' with hinge piece. (0118)
87. FRSI Blanket from Payload Bay Door, approximately 1'6" × 2'0". (0119)
88. Payload Bay Door FRSI & Outer Skin. (0122)
89. Payload Bay Door FRSI & Outer Skin. (0123)

90. Radiator Panel, 2' × 16". (0124)
91. Radiator Panel, 2'6" × 3'. (0125)
92. Radiator Panel, 30" × 21". (0126)
93. Nose Landing Gear Door, R/H. (0127)
94. Lower Skin Forward Fuselage. (0128)
95. R/H Wing Skin/MLG Door. (0129)
96. R/H Lower Wing, MLG Wheel Well. Forward Bulkhead. (0130)
97. R/H Gear Door Leading. (0131)
98. #1 Engine Dome Heat Shield. (0132)
99. LVO1 Left OMS Forward. (0133)
100. LVO1 Left OMS Pod Door. (0134)
101 R/H Upper Wing Glove $X_0$850. (0135)
102. Avionics Bay 4. (0136)
103. Mid-Forward R/H Radiator. (0137)
104. Panel with W/H. (0138)
105. Hydraulic Line Forward Fuselage. (0139)
106. Radiator Panel. (0140)
107. Radiator Panel. (0141)
108. Radiator Panel. (0142)
109. Radiator Panel. (0143)
110. Radiator Panel. (0144)
111. Radiator R/H #3 Forward Hinge Line. (0145)
112. R/H OMS Pod Skin Center Forward. (0146)
113. L/H Payload Bay Door #1. XO 640. (0147)
114. L/H Payload Bay Door, XO 1050 ZO410. (0148)
115. L/H Pod Forward, XO-1320 ZO-90. (0149)
116. R/H Payload Bay Door XO-850. (0150)
117. L/H OMS Pod Aft Outboard. (0151)
118. L/H Forward Panel #1 Radiator. (0152)
119. R/H Inboard Elevon Trailing Edge. (0153)
120. Radiator Section. (0154)
121. OMS Pod Skin R/H Forward Outboard. (0155)
122. Radiator Skin. (0156)
123. L/H OMS Pod Skin & A FRSI Blanket. (0157)
124. Elevon Section. (0158)
125. OMS Pod Skin & A FRSI Blanket. (0159)
126. OMS Pod Skin & A FRSI Blanket. (0160)
127. OMS Pod Skin & A FRSI Blanket. (0161)
128. OMS Pod Skin & A FRSI Blanket. (0162)
129. Elevon Trailing Edge, location unknown. (0163)
130. R/H OMS Pod Forward Outboard Skin & A FRSI Blanket. (0164)
131. L/H OMS Pod Forward Outboard Skin & A FRSI Blanket. (0165)
132. L/H OMS Pod Forward Outboard Skin & A FRSI Blanket. (0166)
133. L/H OMS Pod Aft Inboard Skin & A FRSI Blanket. (0167)
134. L/H OMS Pod Forward Inboard Skin & A FRSI Blanket. (0168)
135. L/H OMS Pod Forward Inboard Skin & A FRSI Blanket. (0169)
136. Engine Dome Heat Shield. Engine unknown. (0170)
137. L/H OMS Pod Aft Outboard Skin & A FRSI Blanket. (0171)
138. L/H Upper Leading Edge Carrier Panel #1. (0172)
139. Tube O_2 Tank/Vent Line Liquid Oxygen. (0173)
140. R/H Body Flap R/H End. (0174)
141. Body Flap L/H End. (0175)
142. Inboard R/H Elevon. (0176)
143. Forward Fuselage Lower R/H. (0177)
144. Forward Fuselage Lower L/H. (0178)
145. Lower R/H Wing Skin, Outboard of MLG. (0179)
146. Forward Fuselage Lower Center. (0180)
147. Payload Bay Door FRSI & Graphite Epoxy. (0181)
148. L/H "A" FRSI, OMS. (0182)
149. R/H "A" FRSI, OMS. (0183)
150. R/H OMS, "A" FRSI. (0184)
151. L/H OMS, "A" FRSI. (0185)
152. R/H OMS, "A" FRSI. (0186)
153. Forward OMS, "A" FRSI. (0187)
154. OMS, "A" FRSI. (0188)
155. OMS, "A" FRSI. (0189)
156. Nose Cap Fairing. (0190)
157. O_2 Tank #4, Fill Vent Supply Relief. (0191)
158. Radiator Panel. (0192)
159. Wing Upper Surface, FRSI & Tile. (0193)
160. R/H Upper Wing Glove. (0198)
161. Radiator Panel. (0201)
162. Dome Heatshield. (0202)
163. Dome Heatshield. (0203)
164. Umbilical Actuator Hi-Temp Insulation Blanket. (0204)
165. O_2 Tank #3, Fill Vent Supply. (0205)
166. Gold Insulation Blanket. (0206)
167. Gold Insulation Blanket. (0207)
168. Gold Insulation Blanket. (0208)
169. Payload Bay Honeycomb. (0209)
170. Wing Honeycomb. (0210)
171. Radiator Panel. (0211)
172. Payload Bay FRSI & Graphite Epoxy. (0212)
173. Radiator Panel & Assorted Hardware. (0213)
174. Payload Bay Door Graphite & Epoxy. (0214)
175. Forward Fuselage Stringer LG. (0215)
176. Forward Fuselage Stringer LG. (0216)
177. Nose Landing Gear Door Gap Filler. (0217)
178. Payload Bay Door Panel, Graphite Epoxy, 3 Ea. (0218)
179. Wing Structure Hat Section, 4 Ea. (0219)
180. OMS Area, "A" FRSI. (0220)
181. Panel, Elevon L/H Lower. (0221)
182. L/H Outboard Elevon. (0222)
183. Insulation (line) 2 Ea. same. (0223)
184. Insulation (line) 3 Ea. same. (0224)
185. Upper Wing Honeycomb. (0225)
186. Gap Filler. (0228)
187. Honeycomb. (0229)
188. R/H Inboard Elevon (Outboard Tip). (0235)
189. H_2 Tank 3 Fill, Vent & Supply. (0236)
190. Liquid Oxygen Line Mid-Body. (0237)
191. Liquid Oxygen Line Mid-Body. (0238)
192. Liquid Oxygen Line Mid-Body. (0239)
193. Liquid Oxygen Line Mid-Body. (0240)
194. Liquid Hydrogen & Oxygen Lines Mid-Body. (0241)
195. 2 Brackets attached to Freon Line ⅜ 320 psi. (0242)
196. Freon Line ⅜ 320 psi. (0243)
197. Liquid Oxygen Line Mid-Body. (0244)
198. ⅜ tube "C" shaped Mid-Body. (0245)
199. ⅜ Tube Irregular shape Mid-Body. (0246)
200. ¼" Freon line (tube) Mid-Body. (0247)
201. ¼" Hydraulic Line Insulation. (0248)
202. R/H OMS Pod Forward Outboard. (0249)
203. L/H Nose Landing Gear Door. (0250)
204. L/H Wing Glove XO900 (Mid). (0251)
205. Payload Bay Door Aft Panel, unknown side. (0252)
206. L/H Lower Rudder Fin. (000253)
207. Aft Section Lower Skin XO 1480 YO 050. (000254)
208. R/H Aft Payload Bay side wall, XO1194, XO1307. (000255)
209. RH OMS Pod Aft Center XO1550. (000256)
210. L/H Side FRCS Aft XO350. (000257)
211. L/H Main Landing Gear Wheel Well Upper Surface. (000258)
212. L/H Main Landing Gear Wheel Well Upper Surfaces. (000259)
213. L/H Main Landing Gear Door & Uplock Actuator. (000260)
214. Payload Bay Door R/H #3, XO1120. (000261)
215. L/H Wheel Well Upper Surface. (000262)
216. X_o250 Frame R/H. (000272)
217. Radiator Panel. (000273)
218. Radiator Panel. (000274)
219. FRSI. (000275)

220. Filler Blanket. (000276)
221. R/H OMS Forward & Down. (000277)
222. Gold Blanket. (000278)
223. L/H OMS FRSI. (000279)
224. L/H OMS FRSI. (000280)
225. L/H OMS FRSI. (000281)
226. L/H OMS XP146, YP158. (000282)
227. Liquid Hydrogen Line 44". (000283)
228. Payload Door Panel 93". (000284)
230. Radiator Panel. (000285)
231. Radiator Panel. (000286)
232. Radiator Panel. (000287)
233. Radiator Door. (000289)
234. R/H Main Landing Gear Door. (000291)
235. R/H Inboard Elevon, Inboard Half. (000293)
236. R/H Wing Upper XO1191. (000292)
237. Door Assembly, Grumman. (000294)
238. R/H Upper Door #12 Wing LESS Carrier Panel. (000295)
239. Drain Line Rudder Speedbrake Hydraulic L/H. (000296)
240. Gold Blanket. Insulated lower Canted XO 559.9. (000297)
241. Coolant Duct Cabin Air. (000298)
242. Blankets, Crew Module Outer Surface. (000299)
243. Blanket Aft Fuselage Rate Gyro Inboard ZO289. (000300)
244. Blanket Side, Insulated above sill long XO917. (000301)
245. Blanket Payload Bay Door, XO714.82, XO 725.6. (000302)
246. Blanket Crew Module Outer Surface. (000303)
247. OMS Gold Insulated Blanket. (000304)
248. Gold Insulated Blanket. (000305)
249. Gold Blanket Crew Module Outer Surface. (000306)
250. OMS Gold Insulated Blanket. (000315)
251. OMS Gold Insulated Blanket. (000316)
252. OMS Skin "A" FRSI. (000317)
253. Gap Filler. (000318)
254. Crew Module Outer Surface. XCM 266. (000319)
255. Crew Module Outer Surface. XCM 327. (000320)
256. Dome Heat Shield Engine #—. (000321)
257. L/H Aft Outboard Attach Point #3 OMS. (000322)
258. Payload Bay Door Honeycomb. (000323)
259. Wing Hat Section. (000324)
260. Forward Fuselage Frame Cap. (000325)
261. OMS "A" FRSI & Honeycomb. (000326)
262. OMS "A" FRSI Inboard Lower L/H. (000327)
263. Thermo Blanket Crew Module Upper, XO327.65. (000328)
264. R/H Lower Aft OMS Pod Sidewall. (000329)
265. R/H Sill Area Blanket Side Skin, XO717.00. (000330)
266. Wing, Lower Surface. (000333)
267. Outer Skin Honeycomb. location unknown. (000334)
268. Aluminum Honeycomb, unknown location. (000335).
269. Skin Honeycomb, location unknown. (000336)
270. Avionics Bay Aft. (000337)
271. Aft Avionics Bay. (000338)
272. Honeycomb 2" × 3" (000339)
273. Liquid Oxygen Line 1035 psi Mid-Body. (000340)
274. Liquid Hydrogen Line 320 psi Mid-Body. (000341)
275. Freon 320 psi line. (000342)
276. Purge Vent Drain Duct Elbow, unknown location. (000343)
277. Purge Vent Drain Duct, unknown location. (000344)
278. Purge Vent Drain Duct, unknown location. (000345)
279. Foam Segment Aft Main Feed Line. (000346)
280. Thermal Blankets. (000347)
281. Thermal Blankets. (000348)
282. Thermal Blankets. (000349).
283. Thermal Blanket Mid-Body. (000350)
284. Thermal Blanket Mid-Body. (000351)
285. Thermal Blanket Crew Module. (000352)
286. R/H Elevon Trailing Edge. (000353)
287. Elevon Trailing Edge Honeycomb. (000354).
288. Elevon Trailing Edge Honeycomb. (000355)
289. Hydraulic Line Mid-Body. (000356)
290. Hydraulic Line Mid-Body. (000357)
291. Oxygen Line Fuel Cell Purge. (000358)
292. Flash Evaporator Feedline, XO 582-640, Water line Mid-Body. (000359)
293. Freon Loop #1 Return, Tube ¾", XO900-93F. (000360)
294. ⅜" Tube. (000361)
295. ⅜" Tube 12" long. (000362)
296. ⅜" Tube 34" long. (000363)
297. Freon Loop #2 Supply, ¾" Tube 25" long. XO104F-10F1. (000364)
298. Freon Loop #2 Coldplate Return, ⅜" tube 50" long. XO 1030-10F5. (000365)
299. ⅜" Tube 50" long. (000366)
300. Loop #1 From P/L Heat Exchanger, ¾" tube Freon Mid-Body. (000367)
301. ⅜" tube H_2O line flash evaporator feedline. (000369)
302. Forward Lower Fuselage, XO 447, R/H STGR 6. (000370)
303. ⅜" Tube Water Line 22 psi. (000371)
304. ¾" tube 9" long. (000372)
305. 3 Pieces of Foam tube insulation. Average length 6". (000373)
306. ¾" tube Freon loop #2 from Panel Heat Exchanger (000374)
307. ¾" tube & insulation liquid oxygen 1035 psi. (000375)
308. ¾" tube & insulation Gryo Mid. (000376)
309. ⅜" tube 11" long. Gryo Mid. (000377)
310. ¼" H_2 Tank Pressure Transducer Supply. XO 1035 YO-55. (000378)
311. ¾" tube assembly LO_2 fill & vent XO 693. (000379)
312. ¾" tube liquid hydrogen XO 824, ZO 359, YO 93.88. (000380)
313. ¼" tube liquid hydrogen. (000381)
314. ½" tube liquid hydrogen 320 psi. (000382)
315. ½" tube liquid hydrogen. (000383)
316. ¾" tube liquid hydrogen line tank set 3. (000384)
317. ½" tube liquid oxygen line 4'2" long. (000385)
318. ¾" tube liquid oxygen line, 2' long. (000386)
319. R/H Inboard Elevon Trailing Edge Honeycomb. (000387)
320. Circulating Pump Insulation, 12" × 5". (000388)
321. Circulating Pump Insulation, 10" × 8". (000389)
322. Upper Rib Structure 11½" × 1" long. (000390)
323. Payload Bay Door Skin, 31" × 30", FRSI. (000391)
324. Payload Bay Door Skin & FRSI, 19" × 15". (000392)
325. Radiator Section, 7½" × 4¼". (000393)
326. Cover, 2½" × 5" × ¾". (000394)
327. Section of Sheet Metal, unknown location. (000395)
328. Payload Bay Door Skin 1½" × 10". (000396)
329. Gold Blanket, OCN C41666, V070-361332-037. (000397)
330. Gold Blanket, V070-361080-006, OCN B85860. (000398)
331. Silver Covered (Tape) piece of 4" line approximately 6" long. ID Hydrogen Conditioning line. (000399)
332. LO_2 Supply line V070-454865-117 Mid-Body Line. (000400)
333. Gold Blanket, no part number, approximately 4' × 5". (000402)
334. Rudder Speed Brake R/H Lower Panel. (000403)
335. Base Heat Shield @ Left OMS Interface Engine #1 (SSME). (000404)
336. Base Heatshield L/H Side @ SSME #1, 2 & 3. (000405)
337. R/H Wing Lower Wing Glove with 2 RCC "T" panel areas/RCC #15 & #16. (000406)
338. R/H Wing RCC Area with RCC Panels #1, 2 & 3. (000407)
339. FRCS Upper Forward Leading Edge. (000408)
340. Upper FRCS. (000409)
341. Mid Fuselage Lower, XO 1040. (000410)
342. Lower Mid R/H XO 919. (000411)

343. Insulated Tubing V070-454866-113, OCN E60482. (000412)
344. Lower Forward Fuselage L/H Aft of Nose Cap. (000413)
345. Upper Forward Body Flap. (000414)
346. Forward Fuselage just aft of nose RCC. (000415)
347. Lower Fuselage. (000416)
348. L/H Chine. (000417)
349. R/H Wing Upper Skin. (000418)
350. R/H Lower Wing Glove. (000419)
351. Mid-Body Floor. (000420)
352. Engine Dome. (000421).
353. Vertical/Stabilizer Lower Forward Skin L/H. (000422)
354. Engine Dome. (000423)
355. Avionics Bay #5. (000424)
356. FRSI and Structure L/H Pod. (000425)
357. L/H Pod Carrier Panel. (000426)
358. Insulated Tubing & Bracket. (000427)
359. Insulated Tubing & Bracket. (000428) .
360. Insulated Tubing. (000429)
361. Insulated Tubing. (000430)
362. Insulated Tubing. (000431)
363. Two Insulated Hydraulic Lines, System #2. (000432)
364. 2 Ea. Insulated Lines & Bracket. (000433)
365. Insulated Oxidizer line & Bracket. (000434)
366. 2 Ea. Liquid Hydrogen (LH_2). (000435)
367. Insulated Line. (000436)
368. Insulated Line Hydrazine. (000437)
369. Insulated Line. (000438)
370. Insulated Line. (000439)
371. Insulated Line. (000440)
372. Insulated Line. (000441)
373. Portion of Radiator Panel + Brackets & 1 Rod. (000442)
374. Line Insulation without line. (000449)
375. Line Insulation with line. (000450)
376. Line insulation without lines, 6 pieces. (000451)
377. Line with insulation & bracket marked as Tank Set #3. F78578, V544-434111-001. (000452)
378. Line with insulation. (000453)
379. Blankets (Pillow), 5 Ea. (000454)
380. Insulated Blanket. (000455)
381. Bracket and 16" Metal Strip. (000456)
382. Line LO_2 Fill & Drain, R/H Aft. (000457)
383. Strut Assembly XO 378.0. Stringer Landing Gear (000458)
384. Forward Cabin ECLSS Bay Air Duct. (000459)
385. Forward Cabin ECLSS Bay Air Duct. (000460)
386. Blanket, Aft Payload Bay Door XO 1100.45, XO 1122.72. (000461)
387. Blanket Side Skin under wiring support. (000462)
388. Forward Fuselage Hat Section. (000463)
389. Forward Fuselage Hat Section. (000464)
390. H_2 Tank 1 & 11 Fill & Vent. XO 693-919. (000465)
391. L/H OMS Pod Outboard Stringer Skin. LVO1. XO 1540, ZO440. (000466)
392. Thermal Blanket 13" × 10" intact. (000467)
393. Thermal Blanket, intact. V408 Kit. (000468)
394. Thermal Blanket Bay 6 Mid-Body Bottom Skin. XO 891, STR 22, R/H. (000469)
395. Mid-Body Lower Frame & Skin Bay 5, 3'7" × 16", L/H. (000470)
396. Thermal Blanket Crew Module Outer Skin, XO 540 6 XO576. (000471)
397. Wire, 3 Ea. Tied at 2 locations 11" long. (000472)
398. 1 Section of Honeycomb 3" × ⅜". (000473)
399. Carrier Panel, #3 from Outboard Elevon X61390. R/H Lower. (000474)
400. Gold Blanket. (000475)
401. Gold Blankets. V070-361693-006, OCN J22451. (000476)
402. Gold Blanket, 1' × 5" × 2', no part number. (000477)
403. Gold Blanket, 1' × 2', no part number, (000478)
404. Stainless Steel 6" × 4" Insulated material, no part number. (000479)
405. Gold & Silver Blanket, no part number, 2' × 4'. (000480)
406. Gold Blanket, 12" × 24", no part number. (000481)
407. Gold Blanket, 2' × 2', no part number. (000482)
408. Tubing insulated 1" × 5", no part number. (000483)
409. Blanket Gold 2" × 4"; no part numbers. (000484)
410. Blanket Gold 2" × 4"; no part numbers. (000485)
411. ME364-0077-0003 S/N 002, Auxiliary Power Unit Water-coolant Tank Insulator. (000486)
412. Blanket Insulation Material, No P/N. (000487)
413. Longeron Fitting Blanket, No P/N. (000488)
414. Longeron Fitting Blanket, No P/N. (000489)
415. Longeron Fitting Blanket, No P/N. (000490)
416. Longeron Fitting Blanket, No P/N. (000491)
417. Gold Blanket, approximately 6" × 8", No P/N. (000492)
418. Longeron Fitting Blanket, No P/N. (000493)
419. Gold Blanket w/Purge Hose & Black Plastic, P/N 73A4009 F12030 (000494)
420. Unknown Pieces, Structure Miscellaneous. (000495)
421. Unknown Pieces, Structure Miscellaneous. (000496)
422. Metal Strip 6" × 4'0", No P/N. (000497)
423. Miscellaneous Longeron Fitting Covers (3 ea), No P/N. (000498)
424. V070-362424-011, OCN B85878 Gold Blanket. (000499)
425. V070-199876-001, S/N 0038, Reinforced Carbon-Carbon. (000500)
426. Metal Strip, approximately 4" × 1" × 5", No P/N. (000501)
427. ME277-0010-0009, Clamp. (000503)
428. V070 326450-002 OCN C34075, Forward Fuselage Bracket. (000504)
429. Skin Structure w/Brackets & Partial Frames. (000505)
430. Section R/H Outboard Elevon Inboard Half. (000506)
431. Radiator Panel Section. (000507)
432. Lower Forward Mid-Fuselage. (000508)
433. Radiator Panel Section w/Roller. (000509)
434. Payload Bay Door, Aft Section #2, Door at Interface with #3. (000510)
435. Line w/Insulation Liquid O_2. (000513)
436. Blankets (2 each). (000514)
437. Blankets (2 each). (000515)
438. Electrical & Hydraulic Access Door, Vertical Stabilizer (partial). (000516)
439. Suspect Dome Heat Shield, Main Engine. (000517)
440. Vertical Stabilizer Top Fin 8' × 3'. (000518)
441. Lower Right Hand Aft Side Wall 8½" × 3'10". (000519)
442. Mid-Body Floor Section (R/H). XO720 to XO870. (000521)
443. Left Hand Main Landing Gear Door Aft, 5'2" × 5'3". (000522)
444. Payload Bay Door, Left Hand #2, 6'1" × 2'4". (000523)
445. Elevon Leading Edge Carrier Panel, Right Hand Outboard, Inboard Tip. (000524)
446. Board Panel Inboard from Outer Tip Right Hand Inboard Elevon Leading Edge Carrier Panel. (000525)
447. R/H Forward Fuselage Upper Skin Above & Aft of Window #6, XO N540. (000526)
448. Lower Wing XON980YON145, Right Hand Glove/Fairing Area, 3' × 3'. (000527)
449. L/H OMS Pod 27" × 7½" "Y" Web Carrier Panel Lower Edge Aft Corner. (000528)
450. Left Hand Fuselage Sidewall Aft Mid-Body, 4½" × 20". (000529)
451. R/H Radiator No. 4 Hinge Line, 27" × 20" (000530)
452. XO 778 Mid-Body Floor & Lower Fuselage Skin, 55" × 24" (000531)
453. Mid-Body Floor & Lower Fuselage Skin, 46" × 12" XO-633. (000532)
454. L/H OMS Pod, Lower Area, 6½" × 16". (000533)
455. R/H OMS Pod Leading Edge, 10" × 34". (000534)

456. Left Main Gear Door Aft Inboard Edge, 32½" × 6". (000535)

457. Bottom Payload Bay XO680 YO – 15 Approximately, ⅜" Tube Assembly, 22 psi Water. (000536)

458. R/H Lower Rudder Speed Brake, 15" × 11" Honeycomb Skin. (000537)

459. Latch Installed, Radiator Section 34" × 27", 1 Ea. (000538)

460. 17" LO_2 or LH_2 Line Insulation Aft Cover. (000539)

461. No P/N – 2 each, Longeron Blankets. (000545)

462. P/N 73A847012-2045 5062P124, Gold Blanket. (000546)

463. Gold Blanket, approximately 1" × 6", No P/N. (000547)

464. Gold Blankets, 2 each, no P/N – 1 each – V070-361297-008 OCN E73179. (000549)

465. Gold Blankets Attached to Each Other, 5 each No P/N; 1 each V070-365441-001 OCN J07223; 1 each V070-365442-001 OCN J07222; 1 each V070-365443-001, OCN None. (000550)

466. Gold Blanket, No P/N. 2" × 3". (000551)

467. Blankets, No P/N. 2 each – Gold 4" × 2'0", 1 each 4" × 12". (000552)

468. Longeron Blanket. No P/N. (000553)

469. Honeycomb Piece, No P/N. 1" × 6". (000554)

470. Blanket Foil, No P/N. Approximately 6" × 1'4". (000555)

471. Left Hand Sidewall LO_2 & LH_2 PRSD Supply Lines. Tank Set 3 & 4 for Mission Kit, No P/N. X_o929-854. (000556)

472. Tubing Assembly, V544-454140-027, V544-454140-029, X_o945.25 (Mid-Body). (000557)

473. Plumbing for LH_2 Tank # 1, X_o843 to X_o880 (L/H Side) No P/N. (000558)

474. O_2 Tank Fill & Vent, P/N V070-454767-008 & 015. 1 Package Insulated Tubing. (000559).

475. Insulated Tubing, No P/N. 1 Piece. Approximately 2' long. (000560)

476. Insulated Tubing, No P/N. 1 Piece. Approximately 7" long. (000561)

477. Payload Bay Door Non-Metallic Material, No P/N. Approximately 4' × 4". 1 Piece. (000562)

478. Piece of Insulated Tubing, No P/N. Approximately 2' × 10" long. (000563)

479. 1 Piece Tubing. No P/N. Approximately 2'0" long (insulated), 1 Piece Blanket Lining. (000564)

480. 1 Piece Tubing Wrap & Insulation. No P/N. (000565)

481. 1 Piece Blanket Stuffing. No P/N. (000566)

482. V525-454010-002; OCN 179295 Insulated Tube Assembly w/Tee Joint. (000567)

483. 1 Piece Electrical Wire, No P/N. Approximately 6'0" long. (000568)

484. Rubberized Ball Joint Item. No P/N. (000569)

485. Liquid Hydrogen Line 30" long. V544-454 1390005-OCN F-77241. (000570)

486. Longeron Blanket XO 1077.5 V070-362237-014; OCN J20351. (000573)

487. Longeron Blanket. V070-364323-024; OCN C25102. (000574)

488. 3" PVD Duct, No P/N, piece approximately 1'0". (000575)

489. 2 each Tube pieces with foam insulation. No P/N. (000576)

490. 1 Piece Tubing with tape and foam cover. No P/N. (000577)

491. 1 Piece Honeycomb, No P/N, approximately 4" × 4" × 1½" (000578)

492. Gold Blanket Right Hand Side Bay 5 Mid-body, P/N V070-362073-006; OCN C26690. (000580)

493. ¼" × 5'0" LO_2 Line with Foam Insulation. No P/N. (000581)

494. 1" × 3' Blanket Strap. No P/N. (000582)

495. Longeron Blanket. No P/N. (000583)

496. 5" Purge Vent Drain Duct, No P/N, piece approximately 1'6" long. (000584)

497. Fixture Assembly with Moveable Arm. P/N 290-30508-26; 290-30501-2. (000587)

498. Miscellaneous Unknown Parts. No P/N. (5 each). (000590)

499. 4 Pieces Miscellaneous Tubing Insulation, No P/N. (000591)

500. Honeycomb from Payload Bay Door, No P/N. 1 Piece. 4" × 1'0". (000593)

501. 1 Piece Blanket Insulation, No P/N. 1 Piece. (000594)

502. Longeron Blanket, No P/N. 4" × 5" (000595)

503. Foamed Tubing, No P/N. 1 Piece, approximately 8" long. (000596)

504. Foamed Tubing, No P/N. 1 Piece, approximately 2'0" long. (000597)

505. Foamed Tubing, No P/N. 1 Piece, approximately 1'6" long. (000598)

506. Fiberglass Sleeving. 1 Piece. No part number. (000599)

507. Miscellaneous Tubing Tape & Insulation. No part number. (000600)

508. Miscellaneous pieces of unidentified foam. No part number. (000601)

509. Multilayer Insulated Blanket Stuffing. No part number. (000603)

510. Cryogenic Line Insulation. No part number. (000604)

511. Miscellaneous pieces insulation. No part number. (000605)

512. Honeycomb. No Part Number. 1" × 4" piece. (000606)

513. Milk Stool – Fiberglass. P/N 70A2805-10/172431-001. (000607)

514. Milk Stool Leg Section. No part number. (000608)

515. Piece of Wing Hat Section. No part number. (000609)

516. Kevlar & Foam Insulation, 4" long. No part number. (000610)

517. Tie Wraps. No part number. (000611)

518. Piece of Filler Bar. No part number. (000612)

519. Piece of rounded metal approximately 6" long. No part number. (000613)

520. Piece of composite part of an elbow. No part number. (000614)

521. Miscellaneous Korponed metal pieces. No part number. (000616)

522. Miscellaneous pieces from landing gear wheel well. No part number. (000617)

523. Miscellaneous parts from Payload Bay Door area. No part number. (000618)

524. Mid-Body Rib @ XO 919 YO105, ZO369, P/N 70C6033-1. (000619)

525. Cable Cover, P/N V408-756200-002, OCN C24514. (000620)

526. Wire Harness Cover R/H Pyro Nose Wheel, P/N V070-772934-001 OCN C16524. (000621)

527. Bracket @ XO 378. V070-320922-001, OCN AEE842. (000622)

528. Payload Bay Wire Tray Cover XO632 to ____. V712-794021-001 OCN PD0754. (000623)

529. Clip @ XO306.32 FRCS Module, V070-316441-001, OCN 504088. (000625)

530. Filler Outboard lower L/H Wing. V070-194181-OT2, OCN AY1818 Gap. (000626)

531. Miscellaneous Mid-Body Wire Tray Cover pieces. No part number. (000627)

532. Mid-Body Wire Tray Cover XO750. V070-340361-013, OCN E67207. (000628)

533. Miscellaneous unknown Honeycomb pieces. No part number. (000629)

534. Miscellaneous Fiberglass pieces. No part number. (000630)

535. Miscellaneous Unknown Blanket Filler pieces. No part number. (000631)

536. Hydraulic Line Support, XO23.0, ZO 430, X1307, V070-350847. (000632)

537. Miscellaneous Unknown Clamp Inserts. No part number. (000633)

538. Some type of Pyro. No part number. (000634)

539. R/H OMS Internal Compartment. 73A310075-2034. (000635)

540. Storage tank pieces. 2 Ea. unidentified. No part number. (000636)

541. Metal Stringer with "No Step" & Gold Blanket. No part number. (000637)

542. Miscellaneous unknown metal pieces. No part number. (000638)

543. Wing Boron Tube piece, approximately 2'0" long. No part number. (000639)

544. Mid-Body Boron Tube piece, approximately 4" long. No part number. (000640)

545. OMS Pod, approximately 1' × 1'8" long. No part number. (000641)

546. Miscellaneous unknown wires. No part number. 000642)

547. Miscellaneous unknown black plastic pieces. No part number. (000643)

548. Miscellaneous unknown possible payload metal, 2 pieces. (000644)

549. Miscellaneous RCC pieces. No part number. (000645)

550. Gold Plastic Sheet approximately 1'0" long. No part number. (000646)

551. Rudder Speed Brake sealing clip piece. 2 Ea. No part number. (000647)

552. Blanket Strap approximately 3'0" long. No part number. (000648)

553. Air Duct with strap and scraps of Gold Blanket. No part number. (000649)

554. Possible Battery Pack. No part number. (000650)

555. Piece of Gold Foil, approximately 5" × 6". No part number. (000651)

556. Miscellaneous pieces of Innertank Metal. No part number. (000653)

557. Possible piece of Mid-Wire Tray Metal, approximately 3" × 4". No part number. (000654)

558. Seal, Graphite Epoxy/RTV & Bulb Material. No part number. (000655)

559. L/H OMS Pod Skin & "A" FRSI. (000658)

560. Radiator Section, 3'2" × 3'6". (000659)

561. L/H OMS Pod Skin & "A" FRSI. (000660)

562. Helium Tank from L/H OMS Pod. P/N MC282-0082-0032 S/N 013. (000663)

563. Helium Tank—3A, P/N MC181-0082-0010, S/N 022. (000664)

564. APU Water Cooling Tank, P/N MC181-0094-0001. (000665)

565. APU Propellant Tank Hydrazine XO1307, P/N MC181-0094-0001, S/N 0008. (000666)

566. Main Propulsion System Helium Tank 40V41TK7, MC181-0082-0010, S/N 0023. (000667)

567. Freon Accumulator Tank, M7J3XSN-485001F. (000668)

568. System 2, Tank 1 XO693 thru XO807, Aft Reaction Pneumatic Control System (ARPCS) MC282-0082-0042, S/N 011. (000669)

569. ARPCS N_2 tank, V61T2408A, Mid-Fuselage, XO582-XO693. MC181-0082-0040, S/N 010. (000670)

570. 40V4A Tank 11, XO1065, MC181-0082-0010, S/N 015. (000671)

571. ARPCS N_2 tank, XO582-XO693; System 1, Tank #2, MC282-0082-0040, S/N 016. (000672)

572. Main Propulsion System Helium Tank, Tank 4A, XO1307, MC181-0082-0010, S/N 012, (000673)

573. FRCS Helium Tank Oxidizer, MC282-0031, S/N 006. (000674)

574. L/H OMS Pod Helium Tank, TK 201, RCS Fuel, MC181-0082-0032, S/N 0010. (000675)

575. Main Propulsion System Helium Tank #9, 40V41, Tank 9, XO1165, YO8625, ZO316.4, MC181-0082-0010, S/N 017. (000676)

576. L/H OMS Pod Tank He, TK 401, MC282-0082-0001, S/N 0010 (000677)

577. HiPoint Purge (MPS) Tank 6, 40V41TK6, MC282-0082-0001, S/N 0010. (000678)

578. PRSD Tank Set #3, XO979-1040 Bay 8—L/H Side. MC282-0063-0200 (No OCN Found) H_2. (000680)

579. PRSD Tank Set #1 H_2. MC282-0063-0200 (no OCN found). (000681)

580. Storage Tank, No part number. Cannot identify. (000682)

581. Honeycomb Metal, piece approximately 1'2" × 1'2" with strut retainers. No part numbers. (000683)

582. Honeycomb Metal, piece approximately 2' × 2'6" with evidence of tile on one side. No part number. (000684)

583. Honeycomb material, 1 Piece 2" thick, 6" × 1'0". No part number. (000685)

584. Gold Blanket, 1 Ea. approximately 1" × 7" long. No part number. (000686)

585. Honeycomb material, 1 Piece 1'0" × 1'6" with tile one side possible body flap cove area Carrier Panel. No part number. (000687)

586. Tube H_2 Tank #3, approximately 1'0" long. V544-454-139-002, OCN A77251. (000688)

587. Tube Assembly H_2 Tank #4, approximately 2' × 6" long. V525-452163-029, OCN AD8753. (000689)

588. H_2 tank #3 Tube 6'0" approximate. V544-454139-011, OCN F77246. (000690)

589. Unidentified tubes, 2 each approximately 2'0" long.

590. Unidentified tubes, 2 each approximately 2'0" long. No part number. (000691).

591. Gap Filler Blanket from inboard fairing L/H OMS Pod. V070-396379-003, OCN CH5180. (000692)

592. Ammonia & Freon Tube ECLSS, Aft Fuselage. V070-635301-004, OCN C48211. (000693)

593. Wing Box Access Door (46-Door) (Left Wing). B91B11302-17A. (000694)

594. Center piece of lower body flap leading edge, approximately 12'0" long. V070-395015-020, OCN 008628. (000695)

595. Radiator Panel piece approximately 1'0" × 3'0". No part number. (000696)

596. Miscellaneous piece of metal approximately 4" × 1'4". No part number. (000698)

597. Graphite Epoxy STR with Supports for Air Supply Duct. 1 Piece. No part number. (000699)

598. Miscellaneous pieces OMS Pod Supply Duct Graphite STR and insulated blanket. No part number. (000700)

599. Gold Insulation Blanket. No part number. (000701)

600. Gold Insulation Blanket. No part number. (000702)

601. Pieces of metal with 4 rivets, 1¼" × 1". (000704)

602. Fluid Line Type IV Insulation, 12" long. (000705)

603. Blanket Insulation, 8" × 5" (000706)

604. Aluminum Structure, 6" × 4". (000707)

605. APU Insulation, 9½" × 3½". (000708)

606. Sheet Metal, 9½" × 2¼". (000709)

607. Sheet Metal, 13" × 2½". (000710)

608. Sheet Metal, 3¾" × 2½". (000711)

609. Sheet Metal, 5" × 3¾". (000712)

610. Payload Bay Door Section, 21 1/2" × 8". (000713)

611. Payload Bay Door Honeycomb, 12" × 3". (000714)

612. Payload Bay Door BellyBand, 37 1/2" × 1". (000715)

613. Purge Vent Duct, 12 1/2" × 1". (000716)

614. Skin & Tile, 12 1/2" × 8". (000717)

615. Dome Heat Shield Section 19" × 8". (000760)

616. Payload Bay Door Section, 23" × 11". (000761)

617. "A" FRSI OMS Pod, 1 1/2" × 20". (000762)

618. 3/8" tube with insulation, & heater wires. (000763)

619. Payload Bay Door Radiator Section 11 1/2" × 3 1/4". (000764)

620. Payload Bay Door Radiator Section, 32" × 16 1/2". (000765)

621. Payload Wire Cable, P/N V5712-774011-002. (000818)

622. Payload Wire Cable, P/N V5712-774012-001. (000819)

623. Payload Wire Cable, P/N V712-7744008-002 (000820)

624. Payload Wire Cable, P/N 46P770735P6501. (000821)

625. Payload Wire Cable, P/N V712-774023-002, OCN P03853. (000822)

626. Payload Wire Cable, P/N V7120774029-002, OCN P04808. (000823)

627. Payload Wire Cable, P/N V712-774021-002, OCN P04742. (000824)

628. Miscellaneous Payload Bay Wire Bundles. (000825)

629. Blanket—FRCS Thruster, P/N V070-39401-002, S/N 003. (000852)

630. Mid-Body Structure 15 1/2" × 9" Irregular, No part number. XO 104 YO + 90. (000853) Mid-Body STR, 6 1/2" × 8" Irregular. No part number. XO 1040 YO + 90. (000854)

631. OMS Pod STR 12" × 23", R/H or L/H. No part number. (000855)

632. OMS Pod Structure 13" × 7", R/H or L/H. No part number. (000856)

633. Boron Tube, (Partial), 20" long. No part number. (000857)

634. Wire Harness, Mid-Body 40" long. P/N V408-774006 (Partial). (000858)

635. Aluminum Sheet Aluminum Sheet Gloss white & Koropon. No part number. (000859)

636. Aluminum Sheet (previously bonded to Honeycomb). No part number. (000860)

637. Aluminum skin & Honeyoomb, Low Reflect Paint. No part number. (000861)

638. Aluminum Sheet + Olive Drab Paint (2 Pcs.). No part number. (000862)

639. Aluminum Can—Partial—Gloss White Surface Coat. No part number. (000863)

640. Partial Line Replaceable Unit (LRU). P/N 62300-01-05-11139, Deutsch 8314. NJ-R123C14. (000864)

641. OMS Pod Stiffener, R/H or L/H Side. PN V070-388916-04, S/N B30993. (000865)

642. Partial Wire Harness, 52" long. No part number. (000866)

643. Payload Bay Door Section, 42" × 13". (000873)

644. Payload Bay Rib Section, 18 1/2" × 3 1/2". (000874)

645. Payload Bay Door Section, 7 1/2" × 4". (000875)

646. Payload Bay Door Section, 16 1/4" × 6 1/2". (000876)

647. OMS Pod Rib Section, 45 1/4" × 4". (000877)

648. OMS Pod Rib & Honeycomb Section, 21" × 9". (000878)

649. Payload Bay Door Honeycomb, 8" × 4". (000879)

650. OMS Pod Rib, 13" × 2 1/2". (000880)

651. Insulation APU Gas Gen Cooling Water Section. 16 1/2" × 9". P/N MB304-0016-006, S/N 009. (000881)

652. Hydraulic Pump Insulation Section, 6" × 4". (000882)

653. Insulation Blanket Section for filter. 8" × 4". P/N MC364-0011-0034, S/N 006. (000883)

654. Mid-Body, Payload Bay Wire Tray Section, 8" × 5 1/4". (000884)

655. Mid-Body Floor Rib, 25" × 2 1/2". (000885)

656. Low Pressure Tank pieces. (3 Ea.) (000886)

657. Payload Bay 8 Blanket Retainer Structure piece, 25¾" × 1". (000887)

658. Mid-Body Side Wall piece, 10½" × 5¼" (000888)

659. Mid-Body Structure piece, 8½" × 2½". (000889)

660. Mid-Body Structure Piece, 6½" × 5¾". (000890)

661. Mid-Body Structure piece, 20½" × 17". (000891)

662. Unknown structure piece, 18½" × ¾". (000892)

663. SSME. High Pressure fuel pump insulation, 21" × 9". (000894)

664. Mid-Body Structure, 13 1/4" × 3 1/4". (000896)

665. Mid-Body Structure, 19 1/4" × 8 1/2". XO609/XO629. (000897)

666. SSME Engine Controller, S/N 2021. (000898)

667. SSME Engine Controller, S/N 2020. (000899)

668. *Engine Controller & Thrust Vector Control* (TVC) Actuator Hydraulic Tubes, P/N V070-585341-145, C29638. (000900)

669. #2 Engine, S/N 2020, Power Head Assembly. (000901)

670. Engine #1 Power Head & Thrust Structure. S/N 2023. (000902)

671. Engine #2, Thrust Plate Structure. (000903)

672. Aft/SSME LH_2 Feed Manifold. (000904)

673. Engine #3 Power Head & Thrust Plate Section. S/N 2021. (000905)

674. Engine #3, Parts off Power Head. (000906)

675. Engine Heat Shield, No. unknown. (000907)

676. Engine Heat Shield, No. unknown. (000908)

677. Engine Heat Shield, No. unknown. (000909)

678. SSME Low Pressure Fuel Duct. (000910)

679. SSME Low Pressure Fuel Pump, RS00-7037-501. (000911)

680. LH_2 Pressure Lines and Manifold. P/N V070-415422-002, BB1913. (000919)

681. Tube Assembly GH_2 Pressure System. P/N V070-415410-025. (000920)

682. Engine Support and Strut, Upper Inboard. P/N V070-351406-001; S/N 2550933. (000921)

683. Aft Fuselage Floor Intercostal. No P/N. (000922)

684. Aft Floor Canted Intercostal. Related. P/N V070-356863-010. (000923)

685. Interface Panel Bracket Assembly, P/N V070-351092-002, B44601. Engine #2. (000924)

686. Hydraulic Tube Assembly System #2 Pressure. P/N V070-585342-123, C53227. (000925)

687. Upper Diagonal Vertical Thrust Strut/Related. P/N V070-351415-001. (000926)

688. Aft Thrust Structure, No P/N. 28" Long. (000927)

689. LH_2 Recirculating Line, P/N MC271-0075-0013, S/N 6503. (000928)

690. External Tank Umbilical Pyrotechnic Canister. P/N V070-565341-001, S/N N06722-1. (000929)

691. External Tank Umbilical Pyrotechnic Canister. P/N V070-565341-001, J42830-13. (000930)

692. Engine #2 Heat Shield Splice Plate. P/N V070-410056-001, AW 2203. (000931)

693. LOX Inlet Prevalve Temperature Sensor, P/N ME 449-0013-0020, S/N 106 V41T1231C. Engine #2. (000932)

694. System #2 Accumulator Return Main Engine Control, V070-585334-007, C51449. (000936)

695. External Tank Umbilical Pyrotechnic Canister Cover. V072-385048-001, AM 2070. (000937)

696. External Tank Umbilical Pyrotechnic Canister Cover, V072-385049-001, N13885. (000938)

697. External Tank Umbilical Pyrotechnic Canister, V070-565341-001, N06722-2. (000939)

698. GH_2 Pressure Temperature Probe, ME 449-0010-0008, S/N 122. V41T1361A. (000940)

699. Structure Support Fitting. P/N V070-352098-001, B45054. Partial. (000945)

700. Main Propulsion System Fuel Recirculation Line, Related P/N ME 261-0045-0008, S/N 103330069275.—Partial. (000946)

701. Main Propulsion System Recirculation Valve Actuator. No P/N. (000947)

702. Space Shuttle Main Engine Heat Shield Doubler, P/N V070-410059-001. (000948)

703. LO_2 Manifold Support Strut. P/N V070-415220-006, F77396. (000949)

704. Main Propulsion System LH_2 Recirculation Line, Related P/N ME 261-0045-0008, S/N 103330068680 —Partial. (000950)

705. Main Propulsion System LOX Solenoid Valve. MC284-0404-0021. (000951)

706. Support Fitting—Thrust Structure Related. No P/N. (000952)

707 Support Fitting—Thrust Structure Related. No P/N. (000953)

708. System Support Fitting—Clamps to Main Engine Thrust Structure. No P/N. (000954)

709. Aft Fuselage Strut, Stability—Upper shelf to Thrust Structure. P/N V070-351509. (000958)

710. Aft Section Wire Tray behind #2 & #3 Engines. (000959)

711. Purge Vent Drain System Bellows, 4" Dia. No P/N. (000960)

712. Pneumatic Tube Assembly. P/N V070-415558-030, C46259. (000961)

713. Hydraulic Tube Assembly—Partial—System #3 Return, P/N V070-585341-164, C19649. (000962)

714. 3" Diameter Cover Plate, P/N 10641192-9 (000963)

715. Tube Assembly GO_2, P/N V070-415460-028, J23092. (000964)

716. LH_2 Inboard Fill and Drain Valve, P/N MC284-0397. (000965)

717. Main Propulsion System Pressure Transducer, P/N ME449-0179-0272, S/N 106. (000966)

718. Main Propulsion System 3-Way Solenoid Valve—Reference Designation LV-18, P/N MC184-0404-0021. (000967)

719. Main Propulsion System Fuel Recirculation Line Clamp, P/N V070-415335-004, J10682. (000968)

720. External Tank Disconnect Purge Flex Hose, P/N ME271-0100-1002, S/N 0003. (000969)

721. LOX Prevalve Actuator, part of MC284-0396-0005. (000970)

722. LH_2 Recirculation Line. Related P/N V070-359046-001, C37222. (000971)

723. Hose Assembly Flexible, Possible Thrust Vector Control Actuator. No P/N. (000972)

724. LH_2 Orbiter/Space Shuttle Main Engine Interface to Low Pressure Fuel Turban Pump—Engine #2. (000995)

725. GOX Pressure Line. 4 Ea. Pieces. (000996)

726. Space Shuttle Main Engine Low Pressure Fuel Duct Bellows, P/N RS008601-221. (000997)

727. Space Shuttle Main Engine Nozzle, Engine Number Unknown. (000998)

728. Engine #1, LH_2 Orbiter/Space Shuttle Main Engine 12" Interfacer to Low Pressure Fuel Turban Pump. (000999)

729. Main Propulsion System Engine #1, LH_2 12" Feedline. (001000)

730. P/N PP9732-000M-002, H37190; Tube Assembly—Partial LO_2 Relief System. (001487)

731. Frangible Nut Canister, External Tank Disconnect External Tank Side, P/N V072-565304-003, BK2288. (001488)

732. Fitting—Part of System Mount Installation Lower Right Hand Vessel, P/N V070-359189-002, C12064. (001489)

733. Doubler, Engine Mounted Heat Shield, P/N V070-410054-001. AC5244-1. (001490)

734. Related P/N V070-351467-027, S/N 874792; Aft Fuse Strut 30" long. (001491)

735. Aft Thrust Structure Section. No P/N. 6" × 6". (001492)

736. Aft Thrust Structure Beam. No P/N. 6' Long. (001493)

737. Partial Main Thrust Structure. No P/N. 7' long. (001494)

738. Section of Main Propulsion System 17" Feedline. No P/N (001495)

739. Section of Main Propulsion System Fill and Drain Line. No P/N. (001496)

740. Section of 17" Feedline—Main Propulsion System. No P/N. (001497)

741. Forward Reaction Control System XO276 CXDTO 299. P/N V070-316444-002, 493405; Clip. (001498)

742. Orbital Maneuvering System Pod Section 13" × 13" Possible Left Hand. No P/N. (001499)

743. Orbital Maneuvering System Pod Section, No P/N 25" × 17". (001500)

744. Aluminum Skin Right Hand Main Landing Gear Door, No P/N.

745. (Milk Stool) Line Support Orbiter Mid-body. P/N 70C6324-1-02 236159-001. (001504)

746. Main Propulsion System LH_2 Manifold & PV16 Recert Valve & SSME #3 LH_2 Prevalve. (001505)

747. Main Propulsion System LH_2 Feedline & Manifold Support Struct. (001506)

748. SSME #1 LPFT Pump & Fuel Turbine Drive Line Duct. (001507)

749. SSME #1 LPFT Pump & Fuel Turbine Drive Line Duct. (001508)

750. LO_2 Turbine Drive Duct. Engine # unknown. (001509)

751. LH_2 Prevalve, Engine #1. (001510)

752. Pyrotechnic MPS LH_2 SSME #2, 12" Feedline. (001511)

753. LO_2 17" Feedline with engine cutoff sensors. (001512)

754. Payload Bay Door Brace. No part number. (001513)

755. Section of Payload Bay Door. No P/N. (001514)

756. Glass fabric/Epoxy Composite. (001515)

757. Fiberglass/Epoxy Material, 3 ¼" × 1". No P/N. (001516)

758. Section of Radiator Skin & Honeycomb. (001517)

759. Aluminum Skin & Honeycomb. (001518)

760. Aluminum Bracket, 3" long. (001519)

761. Part of LH_2 17" Manifold. P/N 13531-11. (001520)

762. Honeycomb, 2 Pieces, 12 sq. inches. No P/N. (001521)

763. Engine Heat Shield Components (Miscellaneous). (001522)

764. SSME Components (Miscellaneous), Engine # unknown. (001523)

765. GO_2 Pressure Sensor Tube Assembly @ 17" LO_2 disconnect. P/N V070-M15344-025 C39776. (001524)

766. Mid-Body Floor Rib Section. XO1040. (001526)

767. Pyrotechnic MPS Prevalve Engine #2 & Recirculating Valve, LH_2. (001527)

768. Engine Nozzle Section, Engine #3. (001528)

769. LO_2 Pyrotechnic MPS Fill & Drain Line, MC271-0076-0002. (001529)

770. Engine Nozzle Feed Line. (001530)

771. Engine Nozzle Section and Vent Line. (001531)

772. Engine Heat Shield Splice Section. (001532)

773. Pressure Transducer. P/N P8158-95C-24-005, S/N 264. (001533)

774. Engine Nozzle Feed Line. (001534)

775. Engine Nozzle TPS. (001535)

776. Piece of Honeycomb Structure with White RTV. (001538)

777. Small Blanket Insulator 4" × 2 ¼". (001539)

778. Bulkhead Blanket Insulator 11" × 7". (001540)

779. Insulator Blanket. P/N 73A847012, S/N 705061P115. (001541)

780. Payload Channel Closure. (001542)

781. L/H Upper Wing Skin & Tile, 72" × 34". – Y50, XO 900. (001544)

782. R/H Aft Side Wall 5-2 Door Area, 9'4" × 12'. (001546)

783. Mid-Body Wire Tray Cover Section. No part number. (001554)

784. Seal 9" Diameter outside 7⅛" I.D. No part number. (001555)

785. Structure—Table, P/N V070-794331-001, G10401. (001556)

786. Orbiter Hardware, miscellaneous. No part number. (001557)

787. Structure piece, part of V070-381012, Related P/N V070-381227-001. (001558)

788. Miscellaneous Orbiter/Structure/System Hardware. No part numbers. (001559)

789. Miscellaneous Electrical Hardware. No part number. (001560)

790. Fiberglass Closeout with 2 connectors. Keel Bridge Payload Bay. No part number. (001561)

791. Gold Blanket—582 Bulkhead. No part number. (001562)

792. Fiberglass Purge Vent Drain Duct—Possible Mid-Body. No part number. (001563)

793. Payload Bay Door Section, No Part Number. (001565)

794. MLG Interior Skin with Honeycomb, 13½" × 6". (001570)

795. SSME & Main Propulsion System Miscellaneous parts from Explosive Ordnance Demolition Area. (001571)

796. Upper Wing Skin & Honeycomb 14½" × 10". (001572)

797. Honeycomb—OMS Pod Area. No part number. (001573)

798. Honeycomb—Payload Bay Door. No part number. (001574)

799. Aluminum Sheet 4" × 8", Orbiter STR. No Part number. (001575)

800. Electrical Component, unknown location. No part number. (001576)

801. Tube Assembly, unknown location. No part number. (001577)

802. R/H Forward Payload Bay side area; Payload Bay Door Section, 96" × 56". XO 576. (001580)

803. L/H Payload Bay sidewall. XO 1260, 45" × 44". Structure Wing Box Area Payload Bay. (001584)

804. Boot Section and mount between 576 & 582, 89" × 1½". (001586)

805. Payload Bay Power Servo Assembly (PSA) Frame. P/N V568-340428-023. (001587)

806. Section of Forward of Structure Outer Skin, 15" × 10". (001588)

807. Boot Section with Mount Frame 576 & 582, 10′ × 1½". (001589)

808. Forward Aft Lower Corner, Window #5, Outer Skin Structure, 33" × 10". (001590)

809. Aft Engine #1, SSME Thrust Beam, Ref. P/N V070-351737-001. (001591)

810. Forward, Tubing, Wires and Section on mount structure. 137" long. (001592)

811. Structure Section Outer Skin, 37" × 7½". (001593)

812. Structure Section, 49" × 13". (001594)

813. Upper Wing Skin L/H Tile & "A" FRSI, 15" × 10½". (001596)

814. Boron Aft Thruster Support 7" Long. (001597)

815. Mid-Body Belly Band, 11½" long. Ref. #0M3105-29. (001598)

816. "T" Structure, 60" × 1¼". (001599)

817. Forward Structure, 24" × 2". (001600)

818. Upper Wing Skin Section, 7½" × 3½". (001604)

819. Payload Bay Blanket, I.D. unknown. (001605)

820. Aft Fuselage, Orbiter Structure with brackets and support rod. (001607)

821. R/H Side K.U. Bank Sill Area with cables, XO 576. (001608)

822. Forward Bulkhead Crew Mid to Forward Fuselage. Nose Landing Gear Assembly. (001610)

823. Forward Fuselage mid-section at FRCS mount flange. (001611)

824. Main Crew Hatch Outboard Structure. Forward Structure Fuselage. XO 575.660 Inboard. (001612)

825. Crew Module Main Hatch Outer Skin Structure. XO 535.750. (001613)

826. Crew Module Main Hatch Seal & Structure. XO 510, ZO 368.00. (001614)

827. Forward Outer Skin Structure L/H Access Door Area. (001616)

828. Forward Outer Skin Structure L/H Side. (001617)

829. Canopy Structure, XO 561.06 to XO 576.66. (001618)

830. Forward Structure Piece (No I.D.). (001619)

831. Forward FRCS Aft Bulkhead Structure, Outboard. (001620)

832. Forward Outer Skin Structure Sidewall. Sta- XO 378 to XO 582. (001621)

833. Forward Window Frame Section, unknown location. (001624)

834. SSME Engine #3 Nozzle 90 degree. (001625)

835. SSME Miscellaneous Electrical Cables & 1 Box. (001627)

836. SSME Miscellaneous Engine Feed and Purge Lines. (001628)

837. Miscellaneous Engine Heat Shield pieces. (4 ea.). (001629)

838. Miscellaneous Engine Nozzle Pieces (5 Ea.). (001630)

839. SSME Miscellaneous Engine parts, 19 pieces. (001631)

840. Main Engine Thrust Support Bracket. Main Propulsion System (001632)

841. Engine Main Feed Line Support, Main Propulsion System. (001633)

842. Engine Thrust Support Beam. Main Propulsion System. (001634)

843. Engine Thrust Support Beam. (001635)

844. Strut Crew Module to Forward Fuselage, R/H. (001643)

845. "S" Band Antenna Upper. (001645)

846. "S" Band Antenna and Structure. (001647)

847. One piece Forward Structure. (001648)

848. Structure—Crew Module Aft Bulkhead 9" × 44". (001650)

849. Rib Section—61" × 4 1/4", (001651)

850. Forward Outer Skin Structure with Dice Tile. (001656)

851. Forward Outer Skin Structure with tile. (001657)

852. Crew Module Overhead Center Structure between windows. (001658)

853. Forward Outer Skin Structure with tile. (001659)

854. Forward Outer Skin Structure with 4 section dice tile. (001660)

855. Pyrotechnic CDF Assembly, AAR-003798, 55340/10314-0002-805. (001666)

856. Pyrotechnic CDF Assembly, AAR-004325, 55340/10314-0002-801. (001667)

857. Pyrotechnic CDF Assembly, AAR-003854, 55340-10314-0001-807. (001668)

858. Pyrotechnic CDF Assembly, AAR-003832, 55340/10314-0002-807. (001669)

859. Pyrotechnic CDF Assembly, AAR-003800, 55340-10314-0002-806. (001670)

860. Pyrotechnic CDF Assembly, AAR-004038, 55340/10314-0002-803. (001671)

861. Pyrotechnic CDF Assembly, AAR-003811, 55340/10314-0002-805. (001672)

862. Pyrotechnic CDF Assembly, AAR-003823, 55340. (001673)

863. 4 Boss Manifold, AAG0000534, 55340-10312-0802-802. (001674)

864. 4 Boss Manifold, AAG0000544, 55340-10312-0002-802. (001675)

865. 4 Boss Manifold, AAG0000527, 55340-10312-0002-801. (001676)

866. Pyrotechnic CDF Assembly, AAR-003865, 55340-10314-0002-809. (001677)

867. Pyrotechnic MPA 01833, SEB26100094 201 R/H 17610. JEE0044. (001678)

868. Pyrotechnic MPA 0021 SEB26100094 101 L/H 17610, JED0229 (001679)

869. Pyrotechnic MPA 0182 SEB26100094 201 R/H 17610, JEE0043 (001680)

870. Pyrotechnic CDF Assembly, AAR-003844, 55340-10314-0002-808. (001681)

871. 2 Boss Manifold, AAG-0000526, 55340-10312-0002-801. (001682)

872. 4 Boss Manifold, AAG-0000543, 55340-10312-0002-802. (001683)

873. 4 Boss Manifold, AAG-0000533, 55340-10312-0002-802. (001684)

874. Pyrotechnic CDF Assembly, AAR-003799, 55340-10314-0002-806. (001685)

875. Pyrotechnic CDF Assembly, AAR-003853, 55340-10314-0002-807. (001686)

876. Pyrotechnic CDF Assembly, AAR-003831, 55340-10314-0002-807. (001687)

877. Pyrotechnic CDF Assembly, AAR-003853, 55340-10314-0002-807. (001688)

878. Pyrotechnic CDF Assembly, AAR-003810, 55340-10314-0002-805. (001689)

879. Pyrotechnic CDF Assembly, AAR-003788, 55340-10314-0002-805. (001690)

880. Pyrotechnic CDF Assembly, AAR-003822, 55340-10314-0002-806. (001691)

881. Pyrotechnic CDF Assembly, AAR-003864, 55340-10314-0002-809. (001692)

882. Pyrotechnic CDF Assembly, AAR-003799, 55340-10314-0002-806. (001693)

883. Pyrotechnic CDF Assembly, AAR-003843, 55340-10314-0002-808. (001694)

884. Pyrotechnic CDF Assembly, AAR-003755, 55340-10314-0002-001. (001695)

885. Pyrotechnic CDF Assembly, AAR-003763, 55340-10314-0002-802. (001696)

886. Pyrotechnic CDF Assembly, AAR-003774, 55340-10314-002-803. (001697)

887. Pyrotechnic CDF Assembly, AAR-003874, 55340-10314-0002-810. (001698)

888. Pyrotechnic MPA 0175, SEB26100094 201 R/H 17610, JEE0037. (001699)

889. Pyrotechnic MPA 0177, SEB16100094 201 R/H 17610, JEE0038. (001700)

890. Pyrotechnic CDF Assembly, AAE0821/0821BE, 55340-10308-0002-801. (001701)

891. Pyrotechnic CDF Assembly, AAE0555, 55340-10308-0003-801 (001702)

892. Pyrotechnic CDF Assembly, AAE0812/0812EE, 55340-10308-0003-801. (001703)

893. Pyrotechnic CDF Assembly, AAE0553/0554BE, 55340-10308-0003-801. (001704)

894. Pyrotechnic CDF Assembly, AAE0500/0133BE, 55340-10308-801. (001705)

895. Pyrotechnic Initiator, AAE-0864/0864, 55340-10308-0003-801. (001706)

896. Pyrotechnic CDF Initiator, AAE0497/0477BEG, 55340-10308-0003-801. (001707)

897. Pyrotechnic CDF Initiator, AAE0775/0775BE, 55340-10308-0003-801. (001708)

898.Temperature Sensor, ME449-0010-0007, 02009-0153. (001709)

899. Temperature Sensor, ME449-0010-0007, 01009-0167. (001710)

900. Temperature Sensor, ME449-0010-0007, 02009-159. (001711)

901. Temperature Sensor, ME449-0010-0007, 02009-0124. (001712)

902. Temperature Sensor, ME449-0010-0007, 01009-0132. (001713)

903. Thruster, AAE00260/AAG00510, 55340-10304-0001-801 & 55340-10305-0001-801. (001714)

904. Thruster, AAE00261/AAG00511, 55340-10304-0001-801/55340-10305-0001-801. (001715)

905. Thruster, AAE00259/AAG00508, 55340-10304-0001-801/55340-10305-0001-801. (001716)

906. Super Zip Dead Block Initiator, 1239536-501 X754 A3836. (001717)

907. Explosive Valve from 50-2 Door bracket. (001719)

908. Explosive Valve from 50-2 Door bracket. (001720)

909. Explosive Valve from 50-2 Door Bracket. (001721)

910. Bulkhead upper structure piece with 4 ea. lines installed XO 378.000. (001732)

911. Possible Aft Flight Deck Structure Aft Coax Tubing. YO15.625 YO58.55. (001733)

912., Retainer Barrier Outer Star Tracker, Orbiter Fiberglass structure with brackets, 14″ × 1½″. (001734)

913. Retainer Barrier Outer Star Tracker, Orbiter Fiberglass structure with brackets, 14″ × 1½″. (001735)

914. Forward structure with tile, 26″ × 4″. (001737)

915. Structure with cloth & zipper. (001738)

916. Forward Vent Door Frame, unknown side. (001739)

917. Water Management ECLSS Equipment Bay structure & tube. (001740)

918. Forward Structure, 5½′ × 2″. (001741)

919. Upper forward XO 535.75 XO 582 Bulkhead structure piece (001742)

920. "S" Band Antenna piece. (001743)

921. Forward structure with tile. (001744)

922. Forward structure with tile. (001745)

923. Forward structure upper with FRSI attached. (001746)

924. Forward structure with 4 Sections diced tile, 10″ × 10″. (001747)

925. Forward structure with tile. (001748)

926. Forward structure with tile. (001749)

927. Forward structure with tile. (001750)

928. Bay 4 L/H Aft Section Avionics Bay Sidewall, 54V76A195. (001751)

929. Payload Bay Door Skin lower section with dice tile. (001753).

930. Forward structure. 37″ × 1 1/4″. (001754)

931. Forward structure. 16″ × 1½″. (001755)

932. Forward structure and Honeycomb, 13″ × 5″. (001756)

933. Small Miscellaneous Forward Structure pieces. 21 Ea. (001757)

934. Forward structure piece, 21″ × 12″. (001758)

935. Forward Structure piece, 16 3/4″ × 4½″. (001759)

936. Inertial Upper Stage Nozzle piece, 3¾″ × 3″. (001760)

937. Possible TDRS Bracket, 4″ × 1″. (001761)

938. Mid-Fuselage Wire Bundle & Brake. (001762) 948. ½″ tube compressed air, 27″ × 17″. (001763)

939. Forward Skin Structure piece with 4 dice tile area 7″ × 5″. (001764)

940. 1½″ Structure Tube, 7¼″ long with one wire and clamp. (001765)

941. Extra Vehicular Activity Handhold on X_o 576 Bulkhead. (001766)

942. SSME No. 2 Engine Nozzle Assembly, S/N 2020. (001767)

943. Aft, Avionics Bay 5 Shelf Level 2. (001768)

944. SSME Engine #1, S/N 2023, Engine Controller. (001769)

945. Forward Structure with screen installed. (001770)

946. Upper R/H Forward Structure Skin with "S" Band Antenna. X_o 576 to X_o 530, 62″ × 36″. (001771)

947. Upper R/H Forward Sidewall Outer Skin Section, 81″ × 139″. (001772)

948. ET/Orbiter Forward Attach Point with Structure (001773)

949. Forward Outer Skin Structure, R/H Sidewall, 43″ × 69″. X_o 576 Area. (001774)

950. R/H Forward Fuselage Upper Structure piece. X_o 378 to X_o 475, Y + 0465. (001775)

951. Forward Structure piece, 98″ × 2″. (001776)

952. Forward Structure piece with FRSI and Tile. 69″ × 12″. X_o 576 Area. (001777)

953. Forward Structure piece with tube support attached. X_o 559.9 lower Forward Fuselage. (001778)

954. Payload Bay, Extra Vehicular Activity Guide Wire Support Bracket & Extra Vehicular Activity Handhold. X_o 582 Area. (001779)

955. Forward Upper Structure Skin with Dice Tile. (001780)

956. Forward Upper Sidewall Structure Skin Piece, 57″ × 34″. (001781)

957. Lower Aft piece of Main Hatch Orbiter Structure, 18″ × 11″. (001782).

958. Forward Structure piece 46″ × 3½″. (001783)

959. Payload Bay Door lock roller & structure section. X_o 576 Area. (001784)

960. L/H Forward Star tracker & Carrier Panel Structure. (001785)

961. Lower piece of Main Hatch Orbiter Structure. (001786)

962. Forward Structure piece Sidewall. (001787)

963. L/H Forward Star Tracker Outer Structure and Carrier Panels. (001788)

964. Side Structure pieces of Nose Landing Gear Cavity. (001789)

965. Main Hatch Structure Support piece. (001790)

966. Forward Structure piece. (001791)

967. Forward Structure piece. 30" × 3". (001792)

968. L/H Forward fitting attach point & structure. (001793)

969. Outer Star Tracker Structure L/H Side. (001794)

970. Forward Structure piece support. (001795)

971. Main Hatch Orbiter Structure piece. (001796)

972. Forward Lower Structure piece, 35½" × 2" (001797)

973. Forward Lower Structure piece, 14" × 2½". (001798)

974. Forward Side Structure piece, 19" × 2¼". (001799)

975. Boron Reinforcing piece strip, 39½" × 1½". (001800)

976. Forward Support Structure piece, 16½" × 1½". (001801)

977. Forward Support Structure piece, 27¼" × 1½". (001802)

978. Forward Structure for Purge Duct Circulator #1. (001803)

979. Forward Structure piece, 13" × 3". (001804)

980. Forward Overhead Window Frame piece, 14½" × 7". (001805)

981. Forward Outer Structure Skin piece, 27" × 4½". (001806)

982. Forward L/H Side Outer Structure piece 38" × 8". (001807)

983. Forward Outer Structure piece Sidewall Upper, 19" × 14". (001808)

984. Forward Outer Structure piece with Honeycomb. (001809)

985. Forward Outer Structure piece Upper Sidewall. (001810)

986. Forward Outer Skin piece. (001811)

987. Forward Outer Skin pieces with Honeycomb. (001812)

988. Forward Structure piece. (001813)

989. Forward Section Tubes & Flex Lines, 4 Ea. (001814)

990. Forward Water Tank Tube & Flex Hoses(dump).(001815)

991. Forward Outer Structure Piece, 8" × 5". (001816)

992. Forward Fuselage Panel Structure. X_o 378 to X_o 447. 11" × 2". (001817)

993. Forward Outer Structure with FRSI, 11" × 3". (001818)

994. Forward Air Duct Support. (001819)

995. Mid-Body Wire & Gold Blanket pieces, 27" long. (001820)

996. Forward Outer Structure piece, 7" × 3". (001821)

997. Forward Inner Structure, 15" × 9". (001822)

998. Miscellaneous Forward Structure pieces, 9 Ea. and 1 Ea. Insulated Blanket. (001823)

999. ET LO_2 or LH_2 Tank Section, 32" × 9". (001824)

1000. Forward Sidewall Structure for FRCS Vent Door. 18" × 9". (001825)

1001. Forward Structure piece Sidewall, 33" × 6¾". (001826)

1002. Forward Structure piece Support, 38" × 2". (001827)

1003. Star Tracker Exterior Door Frame. (001828)

1004. Forward Exterior Structure with section of Carrier Panel, 5" × 8½". (001829)

1005. Forward Exterior Structure, 15½" × 6 3/4". (001830)

1006. Forward Exterior Sidewall Structure with Dice Tile. 40" × 12". (001831)

1007. Bracket Forward Structure Beam Interior, 51 1/2" × 2". X_o 508.1, Y+0058.04. (001832)

1008. Longeron Windshield, upper canopy. Z_o 478.5 Forward Structure piece interior, 31" × 3". (001833)

1009. Forward Exterior Structure piece Upper, 12" × 12". (001834)

1010. Forward Vent Door. X_o 378.00. (001835)

1011. Forward Pressure Cabin Support Strut, 13½" long. X_o 559.9. (001836)

1012. Mid-Body Payload Service Area. Extra Vehicular Activity Handhold. Payload Service Area Access. (001837)

1013. Mid-Body, Payload Service Area. Extra Vehicular Activity Handhold. Payload Service Area Access. (001838)

1014. Window Cavity System, Outboard, 18" × 14". Forward Interior Structure with tube and screen. (001839)

1015. Forward Interior Structure pieces, 40" × 3½". (001840)

1016. Forward Exterior Structure, Upper Section, 29" × 6". (001841)

1017. Forward Exterior Structure. (001842)

1018. Forward Exterior Structure with "S" Band Antenna Upper. (001843)

1019. Duct/Motor & Tube Assembly-Forward, Fuselage Vent Door. (001844)

1020. Carrier Strip Attitude Propulsion System Pod. Forward Interior Structure with Bracket. (001845)

1021. Forward Exterior Structure Brake Lower Forward Fuselage Window. (001846)

1022. Forward Nose Landing Gear Door Aft Link Assembly. (001847)

1023. Forward Interior Structure, Possible Nose Landing Gear, 38" × 12". (001848)

1024. Star Tracker Purge, Forward Interior Structure & Filter Purge System, 5" × 4". (001849)

1025. Forward Exterior Structure Upper with Dice Tile. 18" × 13¼". (001850)

1026. Forward Exterior Structure with Honeycomb. 15½" × 6½". (001851)

1027. Forward Exterior Structure with Dice Tile Upper. 19" × 9". (001852)

1028. Forward Vent Door Structure Mount, 22" × 6". (001853)

1029. Forward Exterior Structure, 10½" × 6½". (001854)

1030. Forward Aft Structure pieces with FRSI, 33½" × 2". (001855)

1031. Forward Exterior Structure, 24½" × 2¼". (001856)

1032. Panel, EMI Shield RCS, Vent, Forward Fuselage. (001857)

1033. Vent Door. (001858)

1034. Upper Forward Fuselage Mate Left Wing. (001859)

1035. Forward Exterior Structure Sidewall piece, 10" × 4". (001860)

1036. Forward Exterior Structure with Honeycomb. (001861)

1037. Forward Exterior Structure, 23" × 5". (001862)

1038. Forward Exterior Structure, 16" × 1 3/4". (001863)

1039. Forward Exterior Structure, 11½" × 1⅛". (001864)

1040. Forward Interior Structure RCS Vent Door Section. (001865)

1041. Exterior Structure Sidewall 9" × 6¼". (001866)

1042. Exterior Structure Piece 8" × 3¾". (001867)

1043. Exterior Structure Piece 6½" × 4¾". (001868)

1044. Forward Interior Structure, 12 Pieces. (001869)

1045. SSME Engine #1 Nozzle, Partial Assembly. (001870)

1046. Forward Exterior Structure Piece w/FRSI Carrier Panel. (001871)

1047. Forward Vent Door Screen & Honeycomb. (001872)

1048. R/H Wing Section 14' Forward of Trailing Edge to Wing Tip, 30' × 14'. (001873)

1049. R/H Wing Section Aft Wheel Well 13' Outboard, 14' × 6'. (001874)

1050. L/H Aft Sidewall with 50-1 Door, 13' × 12'. (001875)

1051. L/H Payload Bay Sidewall Sill Area, Bays 8 thru 12. (001876)

1052. Vertical Stabilizer, Lower Half. (001877)

1053. R/H OMS Pod Tank Aft 1/3. (001878)

1054. L/H Payload Bay Upper Sidewall Section with Payload Bay Door piece, 105" × 23". (001879)

1055. Radiator Section with Freon Lines attached, 61¼" × 28". (001893)

1056. L/H Radiator Control Rods with structure in middle, 78" long. (001894)

1057. R/H Wing Bulkhead Structure Piece, 20½" × 10½". (001895)

1058. R/H Wing Bulkhead Structure Piece, 31" × 29". (001896)

1059. Wing Bulkhead Structure Piece, 10" × 9". (001897)

1060. R/H Wing Upper Structure Piece, 37½" × 18". (001898)

1061. R/H Wing Bulkhead Structure Piece, 38½" × 24". (001899)

1062. Aft Section 50-1 Door Gas Sampling Bracket. (001900)

1063. R/H OMS Pod Tank Skirt Section. (001901)

1064. R/H Wing Spar Structure Piece, 15" × 17½". (001902)

1065. Upper Wing Leading Edge Carrier Panel Half. 13½" × 4½". (001904)

1066. Wing Leading Edge RCC Panel piece. (001905)

1067. R/H Lower Forward Structure piece, 35½" × 14". (001906)

1068. Inner Structure piece, unknown location. 19" × 3¼". (001907)

1069. Upper Forward Structure piece, 16" × 6½". (001908)

1070. Forward Bulkhead Structure piece, 37" × 25". (001909)

1071. Upper Forward X_o Structure Exterior with Dice Tile & FRSI. (001910)

1072. Aft Explosive Valve from 50-1 Door Sampler. (001911)

1073. Aft Explosive Valve from 50-1 Door Sampler. (001912)

1074. Aft Explosive Valve from 50-1 Door Sampler. (001913)

1075. Forward Structure around Nose Landing Gear Area. 5¼" × 10". (001914)

1076. Forward Structure around Star Tracker Section. (001915)

1077. Forward Structure around Star Tracker Section. (001916)

1078. Forward Structure with Filter. (001917)

1079. L/H Forward Star Tracker Actuator & Door. (001918)

1080. Forward Air Duct Mount Bracket. (001919)

1081. Structure Piece, Mid X_o 582, 29½" × 20". (001920)

1082. R/H Wing Bulkhead Station 239, 19" × 21". (001921)

1083. L/H Upper Star Tracker Slide Plate. (001922)

1084. Lower Nose Landing Gear Wheel Well Structure, 27" × 10½". (001923)

1085. Forward Support Strut with brackets, 27" long. (001924)

1086. Forward Vent Door. (001925)

1087. Forward Lower Skin behind Nome Landing Gear Door. 64" × 50". (001926)

1088. Forward FRCS Tank Unit Type. (001927)

1089. L/H Aft Sidewall miscellaneous wire. (001928)

1090. Payload Bay Door Pressure seal, 8 Ft. long. (001929)

1091. Payload Bay Door Seal. Fiber, Total 103". (001930)

1092. R/H Wing Carrier Panel Gap Filler Metal Covers. 5 Each. (001932)

1093. R/H Wing Carrier Panel lower insulation. Station 1340 to 1361. (001933)

1094. R/H Wing Flipper Door Thermo Insulator. (001934)

1095. R/H Wing Support Strut Outboard. (001935)

1096. R/H Wing Support Strut Inboard. (001936)

1097. Structure, Exterior, with FRSI. (001937)

1098. Structure, Exterior, with Tile. (001938)

1099. Structure, Interior, with Access Plate. (001939)

1100. Structure, Interior, V070-310942-001, S/N 229519. (001940)

1101. Hinge Arm, V070-593202-002, S/N 248559. (001941)

1102. Structure, Nose Landing Gear Wheel Well. (001942)

1103. Hat Section Forward Fuselage. No P/N. (001943)

1104. Structure, Forward Fuselage with wiring. V070-592023-001, S/N E73515. (001944)

1105. Structure, Exterior with Tile SIP. (001945)

1106. Structure, Exterior with Tile SIP. (001946)

1107. Structure, Interior. No P/N. (001947)

1108. Structure, Exterior, with Dice Tile. (001948)

1109. Structure, Exterior, with Tile SIP. (001949)

1110. Structure, Exterior, with FRSI. (001950)

1111. Structure, Interior. No P/N. (001951)

1112. Structure, Exterior, with Diced Tile SIP. (001952)

1113. Structure, Exterior, with Tile SIP. (001953)

1114. Structure, Interior, No P/N. 21" × 11". (001954)

1115. Structure, Exterior, with Tile SIP. (001955)

1116. Structure, Exterior, with Tile SIP. (001956)

1117. Access Plate with Structure. V070-381314-001, S/N J25068. (001957)

1118. Hat Section with Exterior Skin & Tile SIP. V070-310111-064, S/N 493009. (001958)

1119. Structure, Exterior, with Access Door. (001959)

1120. Structure, Exterior, with Tile SIP. (001960)

1121. Structure, Interior. No I.D. (001961)

1122. Structure, Interior. No I.D. (001962)

1123. Structure, Exterior, with Access Door. (001963)

1124. Structure, Exterior, with Tile SIP. (001964)

1125. Structure, Exterior, with Tile SIP. (001965)

1126. Miscellaneous Components. No I.D. (001966)

1127. Miscellaneous Components. No I.D. (001967)

1128. Miscellaneous Components. No I.D. (001968)

1129. Structure, Primary Aluminum Beam, 40" long. (001969)

1130. Structure, Primary Aluminum Beam, 36" long. (001970)

1131. Structure, Interior, V070-310948-00X. (001971)

1132. Structure, Interior, V070-31012X00X. (001972)

1133. Structure, Secondary, MR YY2431-000M. (001973)

1134. Structure, Exterior, with Tile SIP. (001974)

1135. Structure, Interior, No I.D. (001975)

1136. Structure, Exterior, with Diced Tile. (001976)

1137. Structure, Exterior, with Tile SIP. (001977)

1138. Structure, Exterior, with Tile SIP. (001978)

1139. Structure, Aluminum Intercoastal, 37" long. (001979)

1140. Structure, Exterior, with Tile SIP. (001980)

1141. Structure, Exterior, with Diced Tile. (001981)

1142. Hat Section, Forward Fuselage. (001982)

1143. Structure, Exterior, with Diced Tile. (001983)

1144. Structure, Interior, with Feed-Thru Boot. V070-337021-001, S/N B679388. (001984)

1145. Structure, Exterior, with Tile SIP. (001985)

1146. Structure, Interior. No P/N. (001986)

1147. Structure, Exterior, with Tile SIP. (001987)

1148. Structure, Interior, Primary. No P/N. (001988)

1149. Structure, Interior, No I.D. (001989)

1150. Fiberglass Support with Tube Assembly. (001990)

1151. Fiberglass Support with Hardline Coax. (001991)

1152. Drive Shaft, V070-592508-00X, S/N F60110. (001992)

1153. Structure, Exterior, with FRSI. (001993)

1154. Structure, Interior, No I.D. (001994)

1155. Aluminum Tube Support, V070-391589-001, S/N B93497. (001995)

1156. Structure, Interior, Primary. No I.D. (001996)

1157. Structure, Interior, Primary. No I.D. (001997)

1158. Structure, Interior, Low Reflective Paint. (001998)

1159. Structure, Exterior, Primary. No I.D. (001999)

1160. Structure, Exterior, Primary with Tile SIP. (002000)

1161. Structure, Interior, with Feed-Thru. (002001)

1163. Structure, Interior, primary. No I.D. (002002)

1164. Structure, Exterior, with Tile Instrumentation. (002003)

1165. Structure, Exterior, with Tile & "A" FRSI. (002004)

1166. Structure, Interior, No I.D. (002005)

1167. Structure, Interior, No I.D. (002006)

1168. Structure, Interior, with Tube Assembly (002007)

1169. Structure, Exterior, with Diced Tile. (002008)

1170. Radiator Section, Payload Bay Door. (002009)

1171. Structure, Interior, No I.D. (002010)

1172. Structure, Interior, V070-320140-010, S/N 190220. (002011)

1173. Structure, Interior, No I.D. (002012)

1174. Structure, Interior, No I.D. (002013)

1175. Structure, Exterior, with Tile SIP and Boron Tube. (002014)

1176. Hat Section, Forward Fuselage, No P/N. (002015)

1177. Structure, Interior, with Tube Assembly. (002016)

1878. Structure, Interior, No I.D. (002017)

1879. Structure, Exterior, with Tile SIP. (002018)

1880. Structure, Exterior, with Tile SIP. (002019)

1881. Structure, Interior. No I.D. (002020)

1882. Structure, Interior, Waffle Pattern. (002021)

1883. Structure, Interior, V070-320866. (002022)

1884. Miscellaneous Components. No I.D. (002023)

1885. Miscellaneous Components. No I.D. (002024)

1886. Miscellaneous Components. Exterior. (002025)

1887. Miscellaneous Components. No I.D. (002026)

1888. Miscellaneous Components. No I.D. (002027)

1889. Miscellaneous Components. No I.D. (002028)

1890. Extra Vehicular Activity Handhold. No I.D. (002029)

1891. Structure, Interior. No I.D. (002030)

1892. Hat Section. No I.D. (002031)

1893. Structure, Interior. No I.D. (002032)

1894. Structure, Interior, with Tube Assembly. (002033)

1895. Structure, Interior, with Tube Assembly. (002034)

1896. Structure, Interior, with adjacent rod end. (002035)

1897. Structure, Interior. No I.D. (002036)

1898. Structure, Interior, with Payload Bay Door Latch Roller. (002037)

1900. Structure, Interior, V070-320754. (002038)

1901. Structure, Interior, 6 Pieces. No I.D. (002039)

1902. R/H Wing Lower Support Beam Piece. (002040)

1903. R/H Wing Miscellaneous Structure Pieces, 7 Ea. (002041)

1904. R/H Wing Upper Structure Section. (002042)

1905. Miscellaneous R/H Wing Gap Fillers (5 Ea.). (002043)

1906. Bulkhead Upper Center, X_o 1307, 8' × 7'3". (002053)

1907. Aft Avionics Bay 4 Control Units, 7 Ea. on Cold Plate. (002054)

1908. Aft Avionics Bay 4 Control Units, 6 Ea. on Cold Plate. (002055)

1909. Aft Flash Evaporator Unit (Complete). (002056)

1910. X_o L/H Side Upper Piece With Payload Bay Door Latches, 3-Each, 8'3" × 1'1". (002058)

1911. Mid-Body Structure with Boron Tube pieces attached. (002059)

1912. Lower R/H Wing Aft Structure, Ax. X_o 1307. (002060)

1913. Payload Bay Door to Longeron Sill Electrical Arm with Wires. (002063)

1914. Aft Miscellaneous 1307 Bulkhead Hydrogen & Nitrogen Lines. 7 Ea. (002064)

1915. Miscellaneous Structure, 5 Pieces. (002065)

1916. Forward Outer Fuselage Structure. (002066)

1917. X_o 1307 Bulkhead Extra Vehicular Activity Handhold. (002067)

1918. Forward Upper Fuselage Structure. ZO 419.00. (002068)

1919. Coax Tube & Wire, W177I500ZA1ZP4. (002069)

1920. Tube Assembly piece, Airlock. (002070)

1921. Forward miscellaneous Aft Structure, 30 pieces. X_o 508. (002071)

1922. Outer Structure, Miscellaneous, 11 pieces. (002072)

1923. Aft Miscellaneous Insulation for Auxiliary Power Unit #2 and Hydraulic Reservoir 1 & 2. (002073)

1924. NSI, Orbiter, 9 Ea. S/N 238, 231, 233, 240, 235, 234, 236, 212, 232. (002075)

1925. Orbiter/ET Forward Separation Bolt, NSI & Bay Plate, 2 Ea. S/N 0013, 0011. (002076)

1926. Crew Module Overhead Window Jettison Tubes. (002077)

1927. Crew Module Miscellaneous AA Batteries, approximately 50 Ea. (002078)

1928. EMU Light Battery, 1 Ea. (002079)

1929. Crew MF71C Camera Bay Batteries, 4 Ea. (002080)

1930. Battery from Spot Light (A16). (002081)

1931. R/H Main Landing Gear & Wheels. (002082)

1932. R/H Wing SPAR X_o 1249 Structure. (002083)

1933. Mid-Body to Wing Interface Lower Skin. YO-105. (002084)

1934. L/H Wing Box Sidewall Mid-Body, X_o 1249. (002085)

1935. Lower R/H Section under Wing Box, X_o 1307 Bulkhead. (002086)

1936. Upper R/H Wing Skin & Structure. (002087)

1937. Upper Wing Box, Mid-Body Floor, Xo 1249, R/H. (002088)

1938. Miscellaneous Freon Tube Assemblies. (002089)

1939. Freon Tube Assemblies, Ref. V070-634062-001, S/N A75434. (002090)

1940. Miscellaneous Tube Assemblies & Bracket, Freon. (002091)

1941. Tube Assembly, ¾" diameter, Freon. (002092)

1942. RCC Panel Wing Leading Edge. (002093)

1943. Fiberglass Support. (HYD-9-04-0158). (002094)

1944. Rate Gyro Assembly, MC493-0015-0011, S/N 21. (002095)

1945. Structure, Mid-Body Sidewall, 60" × 11". (002096)

1946. Miscellaneous Orbiter Structure Components. (002097)

1947. Line Supports with Spring Isolators. (002098)

1948. RCC Panel Pieces, 4 total. (002099)

1949. Wing Hat Section with Struts. (002100)

1950. Wing Hat Section with Struts. (002101)

1951. Electrical Connector Assembly/Freon System. (002102)

1952. Gap Filler, V070-194180-048, S/N AY1862. (002103)

1953. RCC Panel with Structure, (RCC Panel #18 R/H). (002104)

1954. Wing Structure, R/H Upper, 16' × 9'. (002105)

1955. Structure with FRSI. No I.D. (002106)

1956. Structure, Aluminum, 28" long. (002107)

1957. Hat Section, Forward Fuselage Area. No I.D. (002109)

1958. Structure, Aluminum, Rivet Construction. (002110)

1959. Structure, Aluminum, with FRSI, 18" × 3". (002111)

1960. Drive Shaft, V070-592513-002, S/N A08882. (002112)

1961. Structure, Aluminum, 37" × 2". (002113)

1962. Structure with Diced Tile & Whole Tile. (002114)

1963. Miscellaneous Structure Components. (002115)

1964. Structure, Outer Fuselage Tile, V070-391022-049. (002116)

1965. R/H Mid-Body Tubing H_e, 2 Ea. (002117)

1966. R/H Payload Bay Wire Tray Section. (002118)

1967. R/H Payload Bay Wire Tray Lower Section. (002119)

1968. R/H Payload Bay Wire Tray Section. (002120)

1969. R/H Payload Bay Wire Tray Lower Section. (002121)

1970. Payload Bay Wire Tray Lower Section. (002122)

1971. Payload Bay Wire Harness & Structure Section, X_o 582 Aft to X_o 933. (002123)

1972. Payload Bay Structure with Cable Harness, X_o 582 to X_o 933. (002124)

1973. Payload Bay 3 Avionics Platform piece with wire. X_o 582 to X_o 933. (002125)

1974. Payload Bay Connector Panel R/H. X_o 807. (002126)

1975. Payload Bay Wire Tray Lower Section. (002127)

1976. Payload Bay Wire Tray with Wire Cables. (002128)

1977. Payload Bay Struct Fitting, X_o 636. (002129)

1978. Payload Bay Wire Tray Structure, R/H. X_o 693. (002130)

1979. Payload Bay Wire Tray Structure. (002131)

1980. Riser Orbiter Wire Tray Mid-Body. (002132)

1981. Miscellaneous Mid-Body Structure Pieces. (002133)

1982. Payload Bay Wire Tray Riser Structure Piece. (002134)

1983. Payload Bay Wire Tray & Harness Section, X_o 693. (002135)

1984. Payload Bay Cross Beam Structure Pieces. (002136)

1985. Payload Bay Wire Tray Section with Wire Harness. (002137)

1986. Payload Bay Wire Tray Section with Wire Harness. X_o 582 to X_o 933. (002138)

1987. R/H Payload Bay 3 Main Power Distribution Units No. 3. (002139)

1988. Payload Bay D.C. Current Sensors, 3 Ea. (002140)

1989. Aft Avionics Bay 4 Wire Harness & Structure. (002150)

1990. R/H Wing Leading Edge RCC Panels. (002151)

1991. R/H Main Landing Gear Outboard Sidewall with Wing Access Door. (002152)

1992. Aft LO_2 Bolt Attach Structure, X_o 1307. (002153)

1993. L/H Aft 1307 Bulkhead Structure piece with Rate Gyro. (002154)
1994. R/H Wing Upper Skin Structure. (002155)
1995. R/H Fuselage/Wing joining Structure with Inboard Aft Main Landing Gear Sidewall. (002156)
1996. R/H Wing Upper Skin Structure & Center Bulkhead Piece. (002157)
1997. R/H Upper Center Wing Skin & Structure with Bulkhead. (002158)
1998. Payload Bay Upper Wing Box Structure. (002159)
1999. R/H Wing Upper Skin & Structure Piece. (002161)
2000. R/H Wing Upper Skin & Structure Piece. (002162)
2001. Mid-Body Wing Box Bulkhead Piece. (002163)
2002. Mid-Body Wing Box Support Structure. (002164)
2003. R/H Wing Leading Edge RCCF Panel Pieces, 14 Ea. (002165)
2004. Lower R/H Wing Leading Edge Carrier Panel Piece. (002166)
2005. R/H Mid-Body Wire Tray Wire Bundles. (002167)
2006. Structure, R/H Wheel Well, Forward Wall. (002168)
2007. Gyro Tank, Partial. MC282-0063-0300, S/N 07399 & XT0018. (002169)
2008. Structure, L/H Mid-Body Wing Box Interface. (002170)
2009. Cable Support Structure, V070-795403-001, S/N B78738. (002171)
2010. Partial Tank. No I.D. (002172)
2011. Structure, Aluminum Channel with Honeycomb. (002173)
2012. Partial Tank, Inner Tank of VJ Assembly. (002174)
2013. Partial Tank. (002175)
2014. RJDA Aft. MC621-0043-6344. (002176)
2015. RCC Rib Splice Section. (002178)
2016. RCC Rib Splice Section. (002179)
2017. RCC Rib Splice Section. (002180)
2018. RCC Rib Splice Section. (002181)
2019. RCC Rib Splice Section. (002182)
2020. RCC Panel, Partial. (002183)
2021. RCC Panel, Partial. (002184)
2022. RCC Panel, Partial. (002185)
2023. RCC Panel, Partial. (002186)
2024. RCC Panel, Partial. (002187)
2025. RCC Panel, Partial. (002188)
2026. RCC Panel, Partial. (002189)
2027. RCC Panel, Partial. (002190)
2028. RCC Panel, Partial. (002191)
2029. RCC Panel, Partial. (002192)
2030. RCC Panel, Partial. (002193)
2031. RCC Panel, Partial. (002194)
2032. RCC Panel, Partial. (002195)
2033. RCC Panel, Partial. (002196)
2034. RCC Panel, Partial. 11 Pieces, (002197).
2035. Bulkhead Wing Interior Structure with Upper Wing Section. (002198)
2036. Mid-Body Wing Box Structure, Centerline. (002199)
2037. Hat Section Structure, with Strut. (002200)
2038. Hat Section Structure, with Strut. (002201)
2039. Aluminum Strut Structure, 2 Ea. Partial. (002202)
2040. Aluminum Strut Structure, 2 Ea. Partial. (002203)
2041. Mid-Body Structure with Boron Tube Sections. (002204)
2042. Aluminum Strut Structure, Wing Interior. (002205)
2043. Boron Tubes Structure, 3 Ea. Connected. (002206)
2044. R/H Wing Structure, Lower Surface, $Z_o + 167$, Y_o 1290. (002207)
2045. Aft Fuselage Structure, Lower, area of Bay 6. (002208)
2046. Wing Lower Surface Structure. (002209)
2047. Wing Lower Surface Structure. 2 Pieces. (002210)

EXTERNAL TANK (ET) COMPONENTS)

1. Intertank Panel Segment 55" × 50". (0002)
2. Intertank Panel Segment 62" × 41". (0005)
3. Intertank Panel Section, 108" × 129". (0007)
4. LOX Feedline Fairing. (0008)
5. LH_2 Panel, 3rd Hard Point. 188" × 135" (00064)
6. LO_2 Tank Aft Dome Segment. 170" × 23". (00065)
7. Intertank Panel Segment, 62" × 72". (0066)
8. Intertank Panel Segment, 32" × 50". (0067)
9. Intertank Panel Segment, 52" × 90". (0071)
10. Intertank Panel Segment, 18" × 43". (0072)
11. Intertank Panel Portion, 129" × 60". (0073)
12. Intertank Panel Portion, 128" × 36". (0074)
13. Intertank Thrust Panel Segment, 25" × 136". (0075)
14. Intertank Panel Portion, 42" × 47". (0076)
15. Intertank Panel Segment, 77" × 42". (0077)
16. Intertank Panel Segment, 42" × 44". (0078)
17. Intertank Panel Portion, 125" × 29" (0079)
18. Intertank Stringer Panel Segment, 38" × 87". (0081)
19. LH_2 Barrel, 295" × 66". (0083)
20. Intertank Stringer Panel Segment, 35" × 45". (0085)
21. Pressline Fairing (GH_2), 69" long. (0086)
22. Cable Tray Assembly. (0092)
23. Intertank Panel Segment, 27" × 71". (0120)
24. LOX Feedline Segment, 116" long. (0084)
25. Intertank Stringer, 14" × 14". (0196)
26. Intertank Thrust Panel Segment, 126" × 36". (0263)
27. Intertank Panel, 42" × 52". (0265)
28. Cable Tray Assembly Vertical Strut +Y. (0269)
29. Intertank Panel Segment, 44" × 36". (0264)
30. Intertank Thrust Panel, 20" × 102". (0271)
31. Cable Tray Assembly, 19" long. (0230)
32. GO_2 Press Line Bracket, 24" long. (0231)
33. LH_2 Tank Barrel #2 Segment, 177" × 56". (0266)
34. Intertank Thrust Panel, 132" × 10", 140" × 43". (0267)
35. LOX Feedline Segment, 114" long. (0270)
36. Aft Vertical Cable Tray Assembly, 59" long. (0268)
37. LH_2 Barrel No. 2, 245" × 220". (0288)
38. Intertank Thrust Panel, 135" × 23". (0307)
39. Intertank Thrust Panel Segment, 22" × 122". (0308)
40. Intertank Panel Portion, 117" × 67". (0309)
41. Intertank Panel Segment, 65" × 41". (0311)
42. Intertank Panel Segment, 67" × 28". (0312)
43. Intertank Panel +Z, 108" × 129". (0310)
44. Intertank Stringer, 15" × 53". (0313)
45. MA25 & Fragment, 7" × 12". (0059)
46. Intertank Stringer, 5" × 7". (0060)
47. ET Foam. 2" × 3". (0061)
48. ET Foam/Super Light Ablator (SLA) 10" × 10". (0080)
49. LOX Feedline Flanges, 36" × 16". (0082)
50. Intertank Stringer, 43" × 4½". (0087)
51. Barry Mount, 6" × 16". (0197)
52. ET Foam/Super Light Ablator (SLA), 4" × 6". (0232)
53. LO_2 Umbilical Cable Tray & Cover, 10" × 4". (0233)
54. ET Foam/Super Light Ablator (SLA), 10" × 10". (0234)
55. 3 Pieces Intertank Panel Fragment. 8" × 3". (0290)
56. Intertank Stringer, 9½" × 41". (0314)
57. ET Foam (Bag) (16 Pieces). (See Dash H's). (0368)
58. Intertank Stringer, 4" × 13". (0401)
59. Intertank Stringer, 14" × 39". (0443)
60. Intertank Stringer, 12" × 50". (0444)
61. Intertank Panel Segment, 38" × 19". (0445)
62. Intertank Stringer, 4½" × 34". (0446)
63. Intertank Panel Fragment, 24" × 24". (0447)
64. Intertank Panel Segment, 46" × 41". (0448)
65. ET Foam (Bag Containing Foam), 3 Pieces. (0502)
66. Intertank Stringer, 4½" × 41". (0511)
67. Piece of Intertank Panel, 34" × 32". (0512)
68. Intertank Stringer, 4½" × 28". (0541)
69. ET Foam, 23" × 8½". (0542)
70. Intertank Stringer Panel Segment, 40" × 15½". (0543)
71. Piece of Intertank Panel, 24½" × 29". (0544)
72. ET Foam (Bag Containing assorted pieces of foam). (0571)
73. ET Foam, 3" × 4" × 2". (0572)

74. ET Foam (Bag). (0602)
75. ET Foam (Bag). (0605)
76. Bag containing assorted TPS MA25 & SOFI, 5 pieces. (0579)
77. Bag containing assorted TPS, SOFI, 20 pieces. (0592)
78. ET Foam, 7" × 6" × 4". (0697)
79. Forward ET/SRB Bolt Catcher (+4). (0679)
80. Intertank Stringer Segment & 4 Pieces of Tank Stiffener. (0652)
81. Intertank Fragments (5). (0653)
82. Intertank Stringer, 32" × 4½". (0070)
83. Intertank Panel Segment, 151" × 86". (0657)
84. ET Foam (Bag). (0656)
85. ET Nose Cone Assembly. (0661)
86. ET Foam (Bag). Small Fragments. (0703)
87. Aluminum Panel Fragment, 24" × 20". (0846)
88. LH_2 Barrel #1 Segment, 180" × 146". (0847)
89. LH_2 Tank Stiffener Segment. (0851)
90. LO_2 Tank (ogive). (0848)
91. LH_2 Tank Stiffener Segment. (0849)
92. LH_2 Tank Stiffener Segment. (0850)
93. Skin (LO_2/LH_2). (0868)
94. Stringer Panel Skin Segment. (0869)
95. Skin (LO_2/LH_2). (0870)
96. LH_2 Ring Frame Web. (0871)
97. LH_2 Stiffener Segment. (0872)
98. LO_2 Tank Skin (Aft Dome), 74" × 38". (0935)
99. ET/SRB Beam Webbing. (0893)
100. ET LH_2 Tank Skin, 72" × 124". (1543)
101. ET LH_2 Intermed. Ring Frame, 2.3" × 11". (1566)
102. ET/SRB Beam Webbing, 6" × 6". (1567)
103. ET/SRB Beam Webbing, 12" × 7". (1568)
104. ET/SRB Beam Webbing, 14" × 11". (1569)
105. Miscellaneous Foam. (1601)
106. Miscellaneous Foam. (1602)
107. 4 Ea. Cable Tray Assemblies. (1626)
108. LH_2 Cable Tray Assembly, 64" × 6". (1626-1)
109. LH_2 Cable Tray Assembly, 64" × 6". (1626-2)
110. LH_2 Cable Tray Assembly, 64" × 6". (1626-3)
111. LO_2 Cable Tray Assembly, 34" × 5". (1626-4)
112. LH_2 Tank Protuberance Airload "(PAL)" Ramp Segment, 24" × 12". (0368-1)
113. -Y Bipod Ramp, Lower Left Aft Corner, 12" × 7". (0368-2)
114. LH_2 PAL Ramp, 12" × 12". (0368-3)
115. Intertank Two-Tone Fragment, 12" × 6". (0368-4)
116. Intertank Two-Tone Thrust Panel -Z, 14" × 7". (0368-5)
117. LO_2 Tank PAL Ramp (Possible)-Trailing Edge, 12" × 8". (0368-6)
118. LH_2 PAL Ramp Fragment, 15" × 13". (0368-7)
119. +Z Intertank Two-Tone Foam Fragment, 9" × 6". (0368-8)
120. LO_2 Tank Ogive S/A & Foam Fragment, 10" × 8". (0368-9)
121. LO_2 Tank Ogive S/A & Foam, 17" × 8". (0368-10)
122. Intertank Two-Tone Fragment, 15" × 4". (0368-11)
123. Intertank Area BX-250 Closeout (Flange), 8" × 6". (0368-12)
124. 3 Pieces of BX-250 Closeouts, 8" × 10"; 6" × 9"; 7" × 10". (0368-13)
125. Intertank String Foam Fragment, 3" × 7". (0368-14)
126. Intertank Interior Stringer. (02062)
127. LH_2 Tank Skin. (02052)
128. LH_2 Tank Skin. (02177)
129. LH_2 Tank Skin. (02211)

SRB COMPONENTS

1. 2 bags Parts (A)
2. 1 Parachute (B)
3. Foam (C)
4. Foam (D)
5. Elbow & Cutoff Line (E)
6. Miscellaneous Pieces SRB Exterior. No P/N. (F)
7. SRB Nose Cone Frustum, R/H Side. No P/N. (G)
8. Cover Assembly 10751-0001-102, S/N 20000-40. (H)
9. Material, 10182-0083-104, S/N 3000318. (I)
10. Curved Honeycomb & white material. No P/N. 33" × 28". (J)
11. Pieces of various sizes (10), 2-586. No P/N. (K)
12. Piece of Metal, 24" × 12". (L)
13. Nose Cone Frustum #B10-26 left on part. (M)
14. Cover Plate for Booster Separation Motor L/H Thruster. 10752-0002-102 (White) S/N 2000001. (N)
15. Metal Piece, 1 ea., approximately 2'0" × 2'6". (O)
16. Metal Piece, 1 ea., approximately 5" × 8" Long. (P)
17. Metal Piece, 1 ea., approximately 6" × 2.0". (Q)
18. Metal Piece, 1 ea., approximately 2 1/2" × 1.0". (R)
19. Cork Material, SRB Mate Tray, 3" × 2". (S)
20. Structure Attach Point 29" × 15 1/2". (Void)
21. R/H Bootstrap Hydraulic Reservoir. P/N 1711016-005. (T)
22. Hydraulic Fluid Manifold Assembly R/H. No P/N. (U)
23. Miscellaneous Structure Pieces. (V)
24. Section with RSS antenna, 36" × 22", .272 Dia. No P/N (W)
25. SRM O-Ring Section, 62" long, .272 Dia. No P/N. (X)
26. Multi Pin Connector, X13W2RP1, P/N 100013. (Y)
27. Rate Gyro Assembly with attaching structure. No P/N. (Z)
28. Structure Angle—Radius shape, No P/N. (AA)
29. L/H ET Attach Ring Cover, P/N 10751-0033-101, S/N. (BB)
30. Engine Nozzle Section, L/H. (CC)
31. Casing Structure, L/H. 23½" × 4". (DD)
32. Aft Skirt Area Bolt Head, L/H. (EE)
33. Aft Skirt Plate, 3" × 5", L/H. (FF)
34. Engine Nozzle Pieces (2 Ea.), L/H. (GG)
35. Upper Nozzle Structure, L/H. (HH)
36. SRM Tunnel Floor Section. (II)
37. R/H Frustum Vertical Stiffener. (JJ)
38. R/H Frustum Thrust Stiffener. (KK)
39. 52 degree of Outer Leg Clevis. (LL)
40. Electrical Cable, Side unknown. (MM)
41. Rate Gyro Assembly, P/N 101800-005, S/N 030 piece. (NN)
42. Forward Skirt Internal Structure, 19" × 6". (OO)
43. Forward Skirt Internal Structure, 39½" × 14". (PP)
44. Forward Skirt Internal Structure, 20½" × 3½". (QQ)
45. Forward Skirt Internal Structure, 10¾" × 3¼". (RR)
46. Structure with 2 Ea. ¼" line installed. (SS)
47. Forward Skirt Structure with support bracket 69¾" × 11¼". (TT)
48. Forward Skirt Structure, Mates to Item TT. 49" × 10½". (UU)
49. R/H Forward Skirt Thrust Post Adapter Plate. (VV)
50. R/H Forward Skirt Plate with Electronics Box & Cover. (WW)
51. Forward Skirt Inner Structure, 8'7" × 6". (XX)
52. Aft Skirt Thermo Curtain Section. (YY)
53. Structure Piece, 21" × 7". (ZZ)
54. R/H Forward Orbiter Ring Assembly, P/N 10129-0001-107, S/N 20000-15. (AAA)
55. R/H Forward Skirt Structure Piece, 8'6" × 8'4". (BBB)

56. R/H Forward Skirt. (CCC)
57. R/H Miscellaneous Forward Skirt Pieces. (27 Ea.). (DDD)
58. Space Ordnance System Chute Cutters, 12 Ea. (EEE)
59. Main Parachute, S/N 36409. (FFF)
60. Main Parachute, S/N 29234. (GGG)
61. Main Parachute, S/N 36485. (HHH)
62. Forward Skirt Interior Structure Piece. (III)
63. L/H Frustum Drogue Space Ordnance System Chute Cutters. (JJJ)
64. Segment Center Lightweight Case. L/H. (000001)
65. Segment Aft with ET Attachment. L/H. (000002).
66. Segment Piece Center Case, L/H. (000003)
67. Segment Section ET Attach. R/H. 90 degree to 180 (000004)
68. Segment Piece, Standard weight case. 166" × 105". (000005)
69. Segment Piece, R/H, 210" × 164". (000006)
70. 52 degree of Outer Leg Clevis. (000007)
71. R/H Aft Segment Connector to Aft Skirt. (000008)
72. Aft Segment Connector to Aft Skirt. 10'3" × 16'6". (000009)
73. R/H ARCSRB Aft Segment, 7' × 17" Section. (000010)
74. R/H Forward Segment Section. 10'4" × 11'6". (000011)
75. R/H Upper Aft Segment with Tunnel, 14'4" × 10'9". (000012)
76. R/H Segment Section with Tunnel. (000013)
77. R/H Segment Section, Forward Aft Cylinder with Field Joint. (000014)
78. ET Attach L/H Segment Section with Tunnel. (000015)
79. R/H Field Joint Forward Segment Clevis Section. (000016)
80. R/H Aft Skirt Inner Structure, Aft Segment Section. (000017)
81. R/H Aft Segment Section. 36" × 26". (000018)
82. R/H Thermo Curtain Attach Ring. (000019)
83. R/H Aft Skirt Kick Ring Section. (000020)
84. R/H Aft Center Segment Section. (000021)
85. Segment Piece, 1.34" × 80". (000022)
86. Segment Clevis, 8' × 66". (000023)
87. Segment with Clevis, 163' × 140". (000024)
88. Segment Piece with Tang, 6'6" × 5'6". (000025)
89. Segment Piece with Clevis. 88" × 57". (000026)
90. Segment Piece with Clevis & Tang. (000027)
91. Segment Piece with Tang. 9'5" × 9'8". (000028)
92. Segment Piece with Clevis. 10'4" × 10'7". (000029)
93. Segment Piece with no Clevis or Tang. 10'6" × 7'9". (000030)
94. Segment Piece with Clevis & Tang. 4'6" × 13'10". (000031)
95. Segment Piece with Clevis. 11'8" × 4'8". (000032)
96. Segment Piece with Clevis & Tang. (000033)
97. L/H Segment Piece with Double Tang. (000034)
98. Segment Piece with Clevis. (000035)
99. Segment Piece with Clevis. (000036)
100. Forward Segment Clevis of Forward Skirt. (000037)
101. R/H Attach Segment. Location 240 degree-300 degree-320 degree. (000038)
102. R/H Segment Center Forward with Tang & Clevis. (000039)
103. Segment Piece with Tang & Clevis. (000040)
104. Segment Piece. No Tang or Clevis. (000041)
105. Segment Piece Forward or Aft Skirt area. (000042)
106. Segment Piece with Clevis. (000043)
107. Lower L/H SRB ET Attachment Strut with piece of ET Tank. (000044)
108. Segment Piece, No Tang or Clevis. (000045)

INERTIAL UPPER STAGE (IUS)

1. Righthand Aft Frame Tilt Actuator Support Brackets and Tilt-up Springs and Linkages. (585)
2. Lefthand Aft Frame Tilt Actuator Assembly—Aft Portion only. (586)
3. Y-Damper Assembly Portion. (587)
4. Lefthand Slip Ring Assembly. (588)
5. Battery Assembly Portion. (589)
6. Aft Airborne Support Equipment Structure, Internal Structural Plate. (718)
7. Aft Airborne Support Equipment Structure, Internal Cylindrical Skin Structure. (719)
8. Aft Airborne Support Equipment Structure, Belly Skin Section with Stiffeners attached to Aft Face Deck Assembly (Complete). (720)
9. Righthand Low Response Spring Beam. (721)
10. Lefthand Low Response Spring Beam. (722)
11. Lefthand Low Response Spring Beam Outboard Bearing Retainer Ring (Fractured). (723)
12. Aft Airborne Support Equipment Structure, Lefthand Side, 45, Skin Panel. (724)
13. Aft Airborne Support Equipment Structure, Internal Panel, Fractured. (725)
14. Power Control Unit, Assembly, Inboard Portion only. (727)
15. Power Control Unit, Electronic Chassis and Components, Fractured. (728)
16. Power Control Unit, Electronic Component, Fractured. (729)
17. Converter Regulator Unit Power Module, Fractured. (730)
18. Low Response Spring Beam Stop Arm (Internal "K-Bonger"), 2 units total. (739 & 740)
19. Fragmented Aluminum Skin Panel. (741)
20. Fragmented Aluminum and Honeycomb Panel Section. (742)
21. Fragmented Epoxy Encapsulated Wires, Cross-Straps and Terminals. (743)
22. Black Carbon/Carbon Nozzle Strips, Fragmented from SRM-2 Nose Cap Section. (744)
23. Oasis Multi-Strand Cable Bundle, Righthand Side. (745)
24. Printed Circuit Frames from Power Control Unit Assembly. (746)
25. Push-Off Spring Rod with attached Collar. (747)
26. Standard Coupling Ring. (748)
27. 2 Fragmented Metal Strips approximately 3/4" × 4" attached together. (749)
28. Fragmented Portion of Z-Section Stiffener, Aft End of P/N 290-30202-29, from Outboard Surface of Inner Cylindrical Skin. (750)
29. Fragmented Portion of Aft Airborne Support Equipment Structure Inner Skin Panel. (751)
30. Converter Regulator Unit Aft End Panel. (752)
31. Converter Regulator Unit Outboard Cover Panel. (753)
32. Aft Airborne Support Equipment Wire Harness Assembly (Partial). (754)
33. 2' × 3' × 2' Tall Container of Fragmented Wire Harness Assemblies and Aluminum Structural Members. (731)
34. Pyro Switching Unit Fragmented: Top Panel Separated all 4 Side Panels and Bottom Panel Broken. (732)
35. Spacecraft Interface Panel Fragmented with 11-foot Spacecraft Wire Harness Assembly. (733)
36. Fragmented Wire Harness Assembly. (734)
37. Fragmented top Panel of Signal Conditioner Unit-A for Signal Conditioner Unit-B, Outboard Portion of Panel. (735)
38. Printed Circuit Board Assembly. (736)
39. Fragmented Cable Plugs. (737 and 738)
40. Fragmented Forward Cover Panel Assembly from Converter Regulator Unit from Lefthand Backside of Aft Airborne Support Equipment Frame. (755)
41. Fragmented Circuit Board Assembly. (756)
42. Electronic Module Assembly. (757)
43. Multilayer Insulation Assembly Fragments from Solid Rocket Motor-1 (758)
44. Multilayer Insulation Assembly from Propellant Tank Assembly Isolation Valve at 0° or 90°. (759)
45. Thrust Vector Controller-B plus Fragmented Equipment Support Section Structural Members and Electrical Cables. (767)
46. Interstage Top Ring Segment from Approximately 200° to 300°. (768)

47. Redundant Inertial Measurement Unit Assembly. (769)
48. Equipment Support Section Structural Section, Part of Upper Conic Section. (770)
49. Interstage Top Ring from 105° to 180°. (771)
50. Equipment Support Section Structural Section, Part of Upper Conic Section from 200° to 295°. (772)
51. Aft Airborne Support Equipment Backside Skin Panel. (773)
52. Part of Aft Airborne Support Equipment Forward Panel, Upper Portion, 108" Long. (774)
53. Part of Aft Airborne Support Equipment Forward Panel, Lower Portion. (775)
54. Solid Rocket Motor-1 Nozzle Segment, Approximately 14" tall at Area of Nozzle Compliance Ring. (776)
55. Aft Airborne Support Equipment Inner Cylindrical Skin Panel. (777)
56. Aft Airborne Support Equipment Righthand End, 450, Aft Panel. (778)
57. Aft Airborne Support Equipment for Righthand End, Inboard Bearing Assembly for Righthand Low Response Spring Beam. (779)
58. Portion of Interstage Upper Conic Structure from 235° to 250°. (780)
59. Aft Airborne Support Equipment Y-Damper and Centering Spring Assembly, Righthand Aft Unit. (781)
60. Portion of Equipment Support Section Top Ring, Approximately 3 1/2-feet long. (782)
61. Portion of Equipment Support Section Conic Skin 9" × 18". (783)
62. Pushoff Spring Assembly, Fragmented. (784)
63. Part of Equipment Support Section Equipment Deck, Approximately 3-feet long. (785)
64. Aft Airborne Support Equipment Y-Damper Assembly, Righthand Forward. (786)
65. Aft Airborne Support Equipment Y-Damper Assembly, Lefthand Aft. (787)
66. Righthand Slip Ring Assembly. (788)
67. Top Portion of Airborne Support Equipment Converter Regulator Unit N22. (789)
68. Solid Rocket Motor-2 Thrust Vector Controller Actuator from 270° Position. (790)
69. 9, Rocket Engine Module (N37), plus 10" × 18" Section of Equipment Support Section Upper Conic Structure. (791)
70. Part of Battery Assembly. (792)
71. Rocket Engine Module N49, Plus 8" × 20" Section of Equipment Support Section Upper Conic Structure. (793)
72. Outboard Bearing Assembly from Righthand End of Aft Airborne Support Equipment. (794)
73. Power Distribution Unit-A Assembly (N20) from Approximately 286°, Location. (795)
74. Part of Signal Conditioner Unit Forward Panel. (796)
75. Signal Interface Unit Assembly, Completely Fragmented/Smashed. (797)
76. Isolation Diode Assembly. (798)
77. Environment Measurement Unit. (799)
78. Interface Control Unit (N111). (800)
79. Part of Signal Conditioner Unit A or B. (801)
80. Space Ground Link System Transponder. (802)
81. Power Distribution Unit-B. (803)
82. Part of Signal Conditioner Unit A or B. (804)
83. Part of Signal Interface Unit. (805)
84. Part of Signal Interface Unit. (806)
85. Power Amp Assembly. (807)
86. Extendible Exist Cone Hardware, Solid Rocket Motor-2. (808)
87. Staging Receptacle, N75, from Approximately 106.5°, on Interstage Top Ring. (808-1)
88. 11 Printed Circuit Boards and Assemblies from Signal Conditioner Unit A or B. (809)
89. 15 Printer Circuit Boards and Assemblies from Signal Conditioner Unit A or B. (810)
90. Part of Righthand Aft Frame Tilt Actuator Body Section. (811)
91. Portion of Push-off Spring Assembly (1 of 6), from Atop Aft Airborne Support Equipment Frame. (811-1)
92. Miscellaneous Fragmented Cable Assemblies from Equipment Support Section Assembly and Interstage Assembly. (812)
93. Fragmented Battery Parts from Interstage Batteries (8), or from Aft Airborne Support Equipment Batteries (6). (812-1)
94. Rooket Engine Module Solenoid Valve from 189° Rocket Engine Module (N1). (812-2)
95. Outboard End of Spacecraft Interface Connector Panel. (812-3)
96. Fragmented Portion of 1 of 8 Lower Separation Nutcatcher Assemblies. (812-4)
97. Fragmented Portion of P/N 290-30203-3 Inboard Bearing Fitting, Righthand. (812-5)
98. Top Panel Portion of Power Distribution Unit-B (N22). (812-6)
99. Part of Oasis Equipment from Aft Airborne Support Equipment Assembly. (812-7)
100. 3 Broken Pieces of Redundant Inertial Measurement Unit Mounting Frame. (812-8)
101. Fragmented Signal Conditioner Unit A and B on 2½' × 3½' Cardboard. (812-9)
102. Portions of Equipment Support Section Battery Multilayer Insulation Blankets and Interstage Battery Multilayer Insulation Blankets. (812-10)
103. Fragment of 290-30203-J, Aft Airborne Support Equipment Righthand Lower Fitting. (813)
104. Mounting Plate for Power Distribution Unit A and B. (813-1)
105. Curved Channel Member, 30' Long, from Equipment Support Section Internal Structure. (813-5)
106. Part of Aft Airborne Support Equipment Internal Panel. (813-6)
107. Fragment of 23.5° Propellant Tank Assembly, Approximately 12" × 18". (813-7)
108. Portion of Interstage Skin, 14" × 22", from Upper End of Cylindrical Section, from 117.5° to 142°. (813-8)
109. Portion of Interstage Skin, 4-feet Long, Containing Battery Installed Mounting Stringers. (813-9)
110. Portion of Interstage Internal Structural Ring at Interstage Contour Break, 4" Wide × 50" Long. (813-10)
111. Portion of Interstage External Cables (2) from Righthand Side and Backside of Interstage. (813-11)
112. Portion of Oasis Cabling from Aft Airborne Support Equipment Frame, from Thermocouple Reference Junction Location (N46). (813-12)
113. Post of Reaction Control System Manifold Tubing, 25" Long, from Approximately 90°, Location, Containing a Line Heater Junction Block. (813-13)
114. Portion of Interstage Upper Conic Section, 14" × 28". (813-14)
115. P/N 290-30203-4 Lefthand Inboard Bearing Fitting. (813-15)
116. Fragment of Equipment Support Section Lower Conic Skin, 3"-8" Wide × 22" Long. (813-16)
117. Largest Section of Interstage Skin and Stringers, 48" Tall × 62" Wide. (813-18)
118. Broken-off Metal Housing 3" × 3 1/4" × ¾" that contains a Collar/Collet/Bushing. (813-19)
119. 2-Feet × 3 1/2-Feet Cardboard Pallet Containing (35) Fragments of Equipment Support Section and Interstage Structures. (814)
120. Section of Interstage Channel Ring Section 24" Long. (814-1)
121. Portion of Equipment Support Section Forward Structural Ring Approximately 30" Long. (814-2)
122. Portion of Equipment Support Section Forward Structural Ring 16" Long. (814-3)

123. Portion of Skin Panel from Equipment Support Section Lower Conic Section at Approximately 255°, 10" × 21". (814-4)

124. 5 Pieces of Solid Rocket Motor-2 Aft I/F Ring, Still Bolted to Fragments of Equipment Support Section Lower I/F Ring. (814-5)

125. Part of Equipment Support Section Lower Conic Structure, Approximately 10" × 28", from Approximately 265° to 305°. (814-6)

126. Part of Equipment Support Section Structure at Outboard Contour Break, Approximately 4" × 30". (814-7)

127. Part of Reaction Control System Manifold Tubing, Heater Strips, Insulation and Heater Wiring from 270° LOC in Equipment Support Section. (814-8)

128. Part of Interstage Forward Structural Ring. (814-9)

129. Part of Equipment Support Section Structure at Outboard Contour Break, from Approximately 310°. (814-11)

130. Section of Solid Rocket Motor-2 Aft I/F Ring, Approximately 42" Long, Still Bolted to 34" Long Section of Equipment Support Section Lower I/F Ring. (814-12)

131. Part of Aft Airborne Support Equipment Backside Skin Panel, Righthand End, Approximately 22" × 24". (814-13)

132. Part of Equipment Support Section Structural Ring at Conic Contour Break. (814-14)

133. Part of 1 of 8 Nutcatcher Assemblies. (814-15)

134. Part of Signal Conditioner Unit A or B Baseplate, Approximately 11" × 13". (814-16)

135. Part of Equipment Support Section Structural Ring at Conic Contour Break. (814-17)

136. Part of Interstage Battery Mounting Stringer, from 84.5° Location. (814-18)

137. Propellant Tank Assembly N52, from 107° Equipment Support Section Location. (815)

138. 2-feet × 3½-feet Cardboard Pallet Containing Approximately 95 fragments of Equipment Support Section and Interstage Structures. (816)

139. Aft Airborne Support Equipment Internal Structural Panel, 17" × 36" with Stiffeners. (816-1)

140. 9" Long Piece of Coax Cabling That Originally Mated to N28 (Power Amp). (816-2)

141. Part of Redundant Inertial Measurement Unit Mounting Frame. (816-3)

142. Part of Cover Panel from Signal Conditioner Unit A or B. (816-4)

143. Part of Solid Rocket Motor-2 Extendable Exist Cone, Individual Extension Unit Support Arm. (816-5)

144. Part of Cover Panel from N22, Airborne Support Equipment Converter Regulator Unit on Aft Airborne Support Equipment Backside Panel. (816-6)

145. Part of 290-30203-5, Righthand Lower, End Fitting Support Panel. (816-7)

146. Microphone Mount from Microphone M-1. (816-8)

147. 3½" × 6" Fragment of Nozzle Cone. (816-9)

148. 3 P/C Board Frames, 7" × 7", from Signal Conditioner Unit A or B Printed Circuit Board Assemblies. (816-10)

149. Part of Aft Airborne Support Equipment Backside Skin Panel from Aft, Left and End of Panel. (816-11)

150. Part of Lefthand Aft Frame Tilt Actuator Mounting Band Assembly. (816-12)

151. Part of Cover Panel from Spacecraft Converter Regulator Unit (N17) on Aft Airborne Support Equipment Backside Skin Panel. (816-13)

152. Internal Bulkhead Panel from Airborne Support Equipment Converter Regulator Unit (N22), on Aft Airborne Support Equipment Backside Skin Panel, Righthand End. (816-14)

153. Nozzle Compliance Ring Bracket from 180° Location on Solid Rooket Motor-2 Nozzle. (816-15)

154. 6 Fragments of Nutcatcher Assemblies. (816-16)

155. Fragment of Battery Case, 4" × 7¼". (816-17)

156. Top Panel from Thrust Vector Controller-A, N21, at Equipment Support Section. (816-18)

157. Part of Battery Case from Aft Airborne Support Equipment Batteries (1 of 6) or from Interstage Batteries (1 of 8). (816-19)

158. Fragments of 23.5° Propellant Tank Assembly. (816-20)

159. Fiberglass and Red Rubber. Cooling Air Outlet from 38.5° Location on Fiberglass Air Distribution Duct Inside the Interstage. (816-21)

160. Segment of Equipment Support Section Internal Structural Members from Equipment Support Section 90° Location. (816-22)

161. Structural Support Frame for Signal I/F Unit (N47) from Equipment Support Section 72° Location. (816-23)

162. Part of Interstage Structure from 252.5° Location. (816-24)

163. Part of Interstage Structure from 33° Location. (816-25)

164. Part of Equipment Support Section Upper Conic Section, 24" × 34" from 10° to 40° Location. (816-25)

165. Staging Plug Mounting Bracket from Equipment Support Section Location 112.5° Assembly P/N 290-24233-9. (816-27)

166. Part of Equipment Support Section Longeron from 67.5° Location. (816-28)

167. Part of Equipment Support Section Top Ring from 67.5° Location. (816-29)

168. Cooling Air Inlet Port from 18° Location on Equipment Support Section Lower Conic Section. (816-30)

169. 48" Long Stringer Fragment from 166° Location on Interstage Cylindrical Section. (816-31)

170. Cooling Air Port from 38.5° Location on Equipment Support Section Lower Conic Section. (816-32)

171. 6" × 24" Section Fiberglass Air Ducting from 33° to 79° Location Inside the Interstage. (816-33)

172. 4" × 12" Fragment from 5° to 10° Area of Interstage Top Ring, Outer Flange. (816-34)

173. 1½" × 2" Fragment of Interstage Longeron for 38° Location. (816-35)

174. Spacecraft Battery Case, N99, 2 Fragmented Pieces (4½" × 5" each). (816-36)

175. Large Section of Interstage Cylindrical Wall, 36" × 50" (Skin Section). (817)

176. 50" Long Piece of Interstage Top Ring, from 60° to 110° Location. (828)

177. 2 Pieces of Solid Rocket Motor-1 Kenlar Motor Case Sidewall. (829)

178. Cover Plate From Computer-B (N54) 131.5°. (830)

179. 36" Long Piece Interstage Upper Ring. (831)

180. 36" Long Piece of Interstage Upper Ring. (832)

181. 5 of 8 Sets of Upper and Lower Separation Nuts. (833)

182. Multilayer Insulation Assembly from Solid Rocket Motor-1 Safe and Arm Mounting Bracket on Interstage at 213° Location. (834)

183. Mounting Bracket Assembly for Solid Rocket Motor-2 Safe and Arm Devices (N7 & N8) from Equipment Support Section 200° Location. (835)

184. Propellant Tank Assembly Isolation Valve Assembly from Equipment Support Section location 90°. (836)

185. Mounting Bracket Assembly for Solid Rocket Motor-1 Safe and Arm Devices from Interstage 213°, Location. (837)

186. 12" Long Piece of Cable W491. (838)

187. Part of Cable Plug P233 Plus 1-foot Long Strip of Gold Cable Wrap Insulation. (839)

188. Fragmented Portions (2) of Battery Cells. (840)

189. 2 Pieces of Black Rubber Material from Solid Rocket Motor-1 Nozzle Area or Case Liner. (841)

199. Part of Reaction Control System Heat Shield Assembly from 9°, Location on Equipment Support Section Upper Conic Section. (842)

191. 12" × 12" Plastic Bag of Interstage Structure Fragments. (842-1)

192. 6" × 14" Piece of Fiberglass Ducting Material from Inside of Interstage. (842-2)

193. 2 Pieces of Equipment Support Section Internal Structural Radial Members from 203° Location. (842-3)

194. 10 to 12 Small Fragments of Wire Braid Material and Teflon Insulation Material from Inertial Upper Stage Wire Harnesses. (843)

195. Part of Solid Rocket Motor-1 Kevlar Case and Aft Airborne Support Equipment, Upper Portion of Super Zip Ring. (912)

196. Part of Aft Airborne Support Equipment Super Zip Ring, Upper Portion. (912-1)

197. 76" Long Strip of Aft Airborne Support Equipment Super Zip Ring, 1" to 4" Wide. (912-2)

198. Part of Aft Airborne Support Equipment Righthand End Plate. (913)

199. Part of Tech Roll Joint Assembly from Solid Rocket Motor-1. (914)

200. 7½" × 17" Piece of Solid Rocket Motor-1, Internal Thermal Boot. (915)

201. 2 6" × 10" Fragments of Contoured Phenolic Structure. (915-1)

202. 2' × 3½' Cardboard Pallet Containing (8) Miscellaneous Fragments of Interstage Structure and Aft Airborne Support Equipment Structure. (916)

203. Part of Aft Airborne Support Equipment Lefthand End Plate. (916-1)

204. Part of Lefthand Aft Frame Tilt Actuator, Forward Housing Fragment. (916-2)

205. P/N 290-30219-8 Spacer and 290-30219-2 Housing from End of Low Response Spring Beam Stop Arm (290-30219-5). (916-3)

206. Part of Interstage Structure from 213°, Sta 290°, Location. (916-4)

207. Part of Aft Airborne Support Equipment Structure. (916-5)

208. P/N 290-30704-9 Anti-Swivel Bracket from Aft Frame Tilt Actuator Mounting Location on Forward End of Righthand Low Response Spring Beam. (916-6)

209. 11" Long Piece of Solid Rocket Motor-1 Forward Interface Ring with 8" Long Piece of Interstage Lower Ring, Still Attached with 2 Fasteners. (916-7)

210. Bracket Assembly from 270° Position on Solid Rocket Motor-1 Compliance Ring. (916-8)

211. 18" × 28" Fragment of -Y 53.77 Web Assembly. (916-9)

212. 10" × 18" Fragment of P/N 290-30203-5 Righthand Lower Fitting. (916-10)

213. 6" × 22" Section of Solid Rocket Motor-1 Aft Interface Ring and Forward Piece of Aft Airborne Support Equipment Aft Skirt. (916-11)

214. P/N 290-30223-4, Righthand Doubler from Forward Skin Panel of Aft Airborne Support Equipment Frame, Righthand End, Lower. (916-12)

215. 5 1/2" × 29" Fragment of Lefthand Upper Fitting Plate, P/N 290-30203-7. (916-13)

216. 12" × 22" Fragment of Aft Airborne Support Equipment Forward Skin Panel, Lefthand End, Upper Corner. (916-14)

217. 11" × 35½" Flat Panel, P/N 290-30202-43, Web, Intercoastal, 1 of 2, from Righthand Lower Section of Frame. (917)

218. 17" × 36" Flat Panel, with 2 Stiffeners. (918)

219. 3" × 60" Strip of Interstage Sta 347.4" Stiffener Ring. (933)

220. 20" × 24" Ziploc Bag Containing (8) Fragmented Electronic Components from Spacecraft Converter Regulator Unit (N17) or Airborne Support Equipment Converter Regulator Unit (N22) on Backside Skin Panel of Aft Airborne Support Equipment Frame. (934)

221. Fragmented Wire Bundle Assembly, 30" Long from Aft Airborne Support Equipment Frame. (941)

222. Lefthand Sidewall of Battery Case. (942)

223. Electronic Component from Spacecraft Converter Regulator Unit (N17) on Lefthand Backside Panel of Aft Airborne Support Equipment. (943)

224. Electronic Component from Spacecraft Converter Regulator Unit (N17) on Lefthand Backside Panel of Aft Airborne Support Equipment Frame. (944)

225. Electrical Cable Assembly (2). (955)

226. 22" × 24" Fragmented Portion of Aft Airborne Support Equipment, Belly Panel, Lefthand End. (956)

227. 3" × 5" Fragmented Connector Bracket. (956-1)

228. 2" × 16" Cable-way Strap from Aft Airborne Support Equipment Cable-way and Protractor Assembly from Lefthand or Righthand of Airborne Support Equipment Frame. (956-2)

229. Push-off Spring Assembly from 244° Location Atop Aft Airborne Support Equipment Forward Panel. (957)

230. Part of Solid Rocket Motor-2 Kevlar Casing, Outer Wall Section. (0973)

231. Part of Solid Rocket Motor-1 Kevlar Casing Sidewall from 90° Quadrant of Solid Rocket Motor-1. (0974)

232. Part of Solid Rocket Motor-1 Sidewall Casing and all of Solid Rocket Motor-1 Aft Dome Section. (0976)

233. IUS Solid Rocket Motor-2 Kevlar Casing. (0975)

234. IUS Battery, Utility Configuration Item No. 290037-A. (0977)

235. IUS Battery, Utility. (0978)

236. IUS Battery Assembly. (0979)

237. IUS Battery Assembly. (0980)

238. Safe and Arm Unit, P/N 290-21005-5, S/N 1108. (0981)

239. Safe and Arm Unit, P/N 290-21005-5, S/N 1101. (0982)

240. Safe and Arm Unit, P/N 290-21005-5, S/N 1107. (0983)

241. Safe and Arm Unit, P/N 290-21005-5, S/N 1095. (0984)

242. Solid Rocket Motor-2 Shielded Confined Detonation Cords and Explosive Transfer Manifold from Solid Rocket Motor-2 Forward Dome. (0985)

243. Propellant Tank Assembly Isolation Valve Assembly from 0° Location in Equipment Support Section. (0986)

244. Part of Super-Zip Tube. (0987)

245. Solid Rocket Motor-2 Flexible Confined Detonating Cords (4). (0988)

246. Computer Memory Retention batteries from Computer-B Equipment Support Section Location 131.5°. (0989)

247. Solid Rocket Motor-2 Thru-Bulkhead-Initiators (2). (0990)

248. NASA Standard Initiators (NSI's) (10 each). (0991)

249. NASA Standard Initiators (NSI's) (11 each). (0992)

250. Part of Solid Rocket Motor-1 Kevlar Casing from Solid Rocket Motor Sidewall. (0993)

251. Fragments of Solid Propellant from IUS Solid Rocket Motor-1 and/or Solid Rocket Motor-2. (No #)

252. 7" × 12" Fragment of Interstage Conic Section. (1501)

253. 20" Long × ¾" Diameter Potentiometer Tube Assembly from Inside the Right and Aft Frame Tile Actuator Unit. (1525)

254. Manually Operated Actuator Assembly/Part of IUS—Stowed in Crew Compartment, Assembly 290-20760-9, S/N-0001. (1644)

TDRS (TRACKING AND DATA RELAY SATELLITE)

1. Spacecraft Platform Section at −Y location near 132 Bracket. (0540)

2. Section of K-Band Antenna Located at top of Antenna Module. (0058)

3. Single Access Antenna Graphite Tube Assembly located at tip of Antenna. (000634)

4. Tracking and Data Relay Satellite to Inertial Upper Stage Adapter Assembly. Part Number 126900. In several fragments, the two largest each have 2 127556-1 longerons in place, feet are missing on all and are still in place on the Inertial Upper Stage. Two large sections of the 127953-1 Ring and several partial Webs P/N 127955 also make up these larger sections. Several loose fragments of webs also present. (0827)

5. Fragments of Inertial Upper Stage/Tracking and Data Relay Satellite Adapter P/N 126900. These segments belong to the

127953-1 Ring at the lower end of the Adapter Assembly. (0813-2, -3, -4)

6. Tracing and Data Relay Satellite/Inertial Upper Stage Adapter Separation Harness. P/N 296265-1. (0733)

7. Fragment of 127951-1 Ring. Tracking and Data Relay Satellite/Inertial Upper Stage Adapter. This section contains 1 separation spring retained P/N 125207. (0814-10)

8. Tracking and Data Relay Satellite/Inertial Upper Stage Adapter Fragment. (0813-17)

9. Spacecraft Module—Lower half of the 127819 Web Fragments, 2 each in area of Propellant Line Feed thru openings and 128542 Connector Bracket with Connector 9168/K01 still mated to it. (0827-2)

10. Spacecraft Module—Largest part of 127879 lower web with 127539 Separation Ring attached. (0826)

11. Single Access Antenna Ribs two Pieces approximately 14" long, one bare fiberglass tube 14". (0895)

12. Partial 128579-2 Blanket Lower Tank. (000646)

ORBITER THERMAL PROTECTION (TILE) COMPONENTS

1. Righthand Lower Outboard Wing, V070-191025-357. (001001)

2. Adjacent Nose Cap, V070-399415-117, OCN-CSG328. (001002)

3. Lower Carrier Panel #15 Righthand, V070-199728-042. (001003)

4. Lefthand Lower Forward, V070-191035-316. (001004)

5. Righthand Lower Wing Trailing Edge Outboard, V070-191025-459. (001005)

6. Righthand Carrier Plate #18, V070-199134-046. (001006)

7. Righthand Lower Wing Leading Edge, V070-191008-189. (001007)

8. Lower Inboard Wing, V070-191008-174. (001008)

9. Lower Forward of Nose Landing Gear Door, No P/N. (001009)

10. Lefthand Lower Forward, V070-391018-148. (001010)

11. Righthand Lower Wing Leading Edge, V070-191023-316. (001011)

12. Righthand Wing Leading Edge, V070-191018-243. (001012)

13. Leading Edge Spar Lower Inboard Wing, V070-191008-184. (001013)

14. Wing Glove Lower Xo-1002, V070-191003-260. (001014)

15. Righthand Lower Inboard Wing, V070-191008-159. (001015)

16. Righthand Lower Inboard Wing Xo-1250, V070-191014-125. (001016)

17. Righthand Lower Wing Leading Edge, V070-191008-058. (001017)

18. Righthand Lower Inboard Wing, V070-191015-168.(001018)

19. Righthand Lower Inboard Wing Xo-1263, V070-191014-159. (001019)

20. Righthand Lower Inboard Wing, V070-191009-121. (001020)

21. Righthand Lower Inboard Wing, V070-191019-090. (001021)

22. Vertical Leading Edge, No P/N. (001022)

23. Righthand Inboard Wing Lower, V070-191019-066. (001023)

24. Righthand Lower Inboard Wing, V070-191008-160. (001024)

25. Righthand Lower Inboard Wing, V070-191010-089. (001025)

26. Righthand Nose Landing Gear Door, V070-391040-076. (001026)

27. Lefthand Forward Reaction Control System, V070-391005-256. (001027)

28. Lefthand Lower Forward, V070-391061-451, OCN-CD0972. (001028)

29. Righthand Lower Inboard Wing, V070-191008-089. (001029)

30. Lefthand Lower Wing Glove, V070-191029-245, OCN-008869. (001030)

31. Righthand Main Landing Gear Door, V070-191037-095, Xo-1100, (001031)

32. Lefthand Forward, Fuselage Lower, V070-391018-166, OCN-009898. (001032)

33. Lefthand Lower Elevon, V070-193016-064. (001033)

34. Lefthand Outboard Lower Elevon, V070-193016-095, OCN-008498. (001034)

35. Lefthand Aft Sidewall, V070-395006-080, OCN-008750. (001035)

36. Body Flap,V070-395034-121, OCN-008812. (001036)

37. Righthand Lower Outboard Elevon, V070-193018-098. (001037)

38. Body Flap, No P/N. (001038)

39. Body Flap, No P/N. (001039)

40. Righthand Wing Leading Edge, V070-191003-274. (001040)

41. Righthand Wing Leading Edge Xo-1263, V070-191014-055, OCN-CLCC14. (001041)

42. Lefthand Lower Forward, V070-391017-090, OCN-008451. (001042)

43. Lefthand Lower Forward, V070-391035-284. (001043)

44. Righthand Upper Wing #3, V070-199005-008. (001044)

45. Righthand Lower Forward, V070-391018-276, OCN-00915. (001045)

46. Righthand Outboard Wing Leading Edge, V070-191023-312. (001046)

47. Righthand Lower Inboard Wing Xo-1278, V070-191013-077, OCN-008631. (001047)

48. Righthand Lower Forward, V070-191018-239. (001048)

49. Righthand Forward Main Landing Gear Door, V070-191131-030. (001049)

50. Trailing Edge Body Flap Upper, V070-395032-168, OCN-008640. (001050)

51. Aft Body Flap Upper Righthand Side, V070-395031-234, OCN-008071. (001051)

52. Outboard Elevon Trailing Edge Righthand, V070-193016-109 (001052)

53. Righthand Lower Inboard Wing, V070-191009-115. (001053)

54. Nose Landing Gear Door, Forward Righthand Outboard Corner, V070-391040-080. (001054)

55. Unidentified Tile Parts. (001055)

56. Unidentified Tile Parts. (001056)

57. Unidentified Tile Parts. (001057)

58. Unidentified Tile Parts. (001058)

59. Unidentified Tile Parts. (001059)

60. Scrap Tile From Ship Deck Point Roberts. (001060)

61. Unidentified Tile Parts. (001061)

62. 2 each Wing Leading Edge. (001062)

63. Vertical Stabilizer Leading Edge. (001063)

64. Forward Lower. (001064)

65. Lefthand Lower YO-100, V070-395039-096 and Gap Filler Pillow. (001065)

66. Forward Lower Front of Main Landing Gear Door, V070-391041-066. (001066)

67. Righthand Main Landing Gear Door Outboard Forward Edge, V070-191121-018, Xo-1100. (001067)

68. Nose Gear Door, V070-191134 Gap Filler and Tile. (001068)

69. Lefthand Aft Sidewall Front of Body Flap, V070-395006-328. (001069)

70. 1—Tile Possibly BHS Carrier Plate. (001070)

71. Righthand Forward Fuselage Sidewall. (001071)

72. Less Carrier Plate Tile. (001072)

73. Lower Body Flap Lefthand, V070-395033-070, Xo1600. (001073)

74. Forward Lower Righthand Just Behind Nosecone, V070-391017-138. (001074)

75. Tile Part from Main Landing Gear Door. (001075)

76. Righthand Lower in Front Main Landing Gear Door, V070-391003-288. (001076)

77. Forward Reaction Control System Lefthand Side Thruster O Panel, V070-391052-193. (001077)

78. Possibly Body Flap Stub Tile. (001078)

79. Lower Forward Fuselage, V070-391035-297. (001079)

80. Righthand Lower Wing Leading Edge, V070-191011-188, Xo-1130. (001080)

81. Carrier Plate Tile. (001081)

82. Righthand Outboard Elevon, V070-193018-056. (001082)

83. Inboard Elevon, V070-193005. (001083)

84. Aft Sidewall Lefthand Lower Forward Corner, V070-395006-398. (001084)

85. Lefthand Forward Software, V070-391016-579. (001085)

86. Lower Mid Xo-650, V070-394047. (001086)

87. Lower Mid Xo-600, V070-394020. (001087)

88. Righthand Lower Wing Aft of Main Landing Gear Door, V070-191014-153. (001088)

89. Lefthand Lower Mid, V070-394021-070, Xo-680. (001089)

90. Lower Mid Center Line V070-394026-046, Xo-1000. (001090)

91. Lower Mid Fuselage,V070-394-xxx-053. (001091)

92. Lower Mid Unidentified Tile Part. (001092)

93. Righthand Lower Mid, V070-394025-125, Xo-900. (001093)

94. Righthand Lower Mid, V070-394048-142, Xo-650. (001094)

95. Righthand Wing Glove Lower, V070-394504-306. (001095)

96. Lower Mid on Tee Outer Edge, V707-394048. (001096)

97. Lower Mid, V070-394024, Xo-800. (001097)

98. Lower Mid, V070-394046, Xo-700. (001098)

99. Lower Mid, V070-394038, Xo-900. (001099)

100. No Part Number, Vertical Stabilizer Leading Edge. (001100)

101. Lower Mid Outer Edge, V070-394048, (001101)

102. No Part Number, Possibly Mid-Body. (001102)

103. Body Flap, V070-395119. (001103)

104. Lower Forward Fuselage Outer Edge, V070-391061 (001104)

105. Lefthand Lower Mid, Xo-700, V070-394021-057. (001105)

106. Mid Lower, V070-394025. (001106)

107. Lefthand Forward Lower Aft of Nose Landing Gear Door, V070-391061-057, (001107)

108. Lefthand Lower Front of External Tank Door, V070-394032-049, OCN-008596. (001108)

109. Wing Glove, No Part Number. (001109)

110. Lefthand Lower Mid, V070-394025-056. (001110)

111. Lower Wing Glove, V070-394504. (001111)

112. Lefthand Wing Glove, V070-394503-179, Xo-680. (001112)

113. Righthand Wing Glove, V070-191028, Xo-800-900. (001113)

114. Wing Glove Lower Aft, V070-394504-276. Xo-756-Xo-813. (001114)

115. Lower Body Flap, V070-395033-083. (001115)

116. Lefthand Lower Inboard Wing, V070-394504-336, Xo-780. (001116)

117. Unidentified Tile Parts. (001117)

118. Unidentified Tile Parts. (001118)

119. Unidentified Tile Parts. (001119)

120. Unidentified Tile Parts. (001120)

121. Left hand Orbital Maneuvering Subsystem Forward Outboard, V070-396451-015, OCN-CH1041. (001121)

122. Lower Forward Fuselage, V070-391017-059, OCN-008352. (001122)

123. Righthand Inboard Elevon Edge, V070-193009-201, OCN-009061. (001123)

124. Orbital Maneuvering Subsystem Low Temperature Reusable Surface Insulation. (001124)

125. Righthand Wing Outboard Adjacent to Main Landing Gear Door Forward Edge, V070-191004-xxx, OCN-008447. (001125)

126. Lefthand Orbital Maneuvering Subsystem Forward Inboard, V070-396450-021, AT-2253. (001126)

127. Lower Fuselage Mid Lefthand Forward, V070-394046-018, OCN-008617. (001127)

128. At Center Line Forward of External Tank Doors, No Part Number. (001128)

129. Righthand Orbital Maneuvering Subsystem Heat Shield Carrier Plate, No Part Number. (001129)

130. Pillow Gap Filler, V070-335054-119. (001130)

131. Pillow Gap Filler, V070-396434-023. (001131)

132. Main Landing Gear Door, No Part Number OCN-F10157. (001132)

133. Lower Wing Glove, No Part Number. (001133)

134. Forward Nose Landing Gear Door Lefthand, No Part Number. (001134)

135. Unidentified Tile Parts. (001135)

136. Unidentified Tile Parts. (001136)

137. Unidentified Tile Parts and Pillow Gap Fillers. (001137)

138. Body Flap Lower. (001138)

139. Lefthand Orbital Maneuvering Subsystem Pod, Carrier Plate V070-394432-001 Pillow Gap Attached, V070-396366-xxx (OV102). (001139)

140. Pillow Gap Outboard Elevon, V070-193036-138, OCN-BP9085. (001140)

141. Lefthand Side of External Tank Attach Point Forward Lower, V070-391045-095, OCN-N02462. (001141)

142. Orbital Maneuvering Subsystem Low Temperature Reusable Surface Insulation, No Part Number. (001142)

143. Right Lower Wing, V070-191035-036, G-19785. (001143)

144. Forward Fuselage, V070-391018-267, OCN-008997. (001144)

145. Body Flap, V070-395034-154, OCN-008705. (001145)

146. Nose Landing Gear Door, V070-391045-110, BC6321, OCN-GH0090. (001146)

147. Forward Fuselage, V070-391016-578, 500024. (001147)

148. Wing Glove Lower Righthand, V070-394504-290, 008642. (001148)

149. Mid-Fuselage, V070-394504-319, 0088, SS8987. (001149)

150. Left Wing Lower, V070-191018-138, OCN-009804. (001150)

151. Mid-Fuselage, V070-394504-238, OCN-008389. (001151)

152. With Gap Filler, V070-191022-147, OCN-CM6819. (001152)

153. Left Wing, V070-199715-043, H23624. (001153)

154. Righthand Lower Carrier Plate, V070-199726-042, CL-7832. (001154)

155. Unidentified Tile Parts. (001155)

156. Lower Wing, V070-191011-190, OCN-009300. (001156)

157. Lefthand Wing Lower, V070-1910005, OCN-00840X. (001157)

158. Forward Lefthand Side Behind Nose, V070-399415-115. (001158)

159. Forward Fuselage, V070-391018-182, OCN-00814-3. (001159)

160. Right Wing Lower, V070-191014-130, CL6636. (001160)

161. Lower Forward Fuselage, V070-39103-xxx. (001161)

162. Right Wing Lower, V070-191003-136, OCN-CL1181. (001162)

163. Vertical Stabilizer Leading Edge. (001163)

164. Less Carrier Plate Tile Lower. (001164)

165. Base Heat Shield Carrier Plate High Temperature Reusable Surface Insulation. (001165)

166. Lower Forward High Temperature Reusable Surface Insulation Tile (Part). (001166)

167. Righthand Lower Wing, V070-191010-057. (001167)

168. V070-391018-033, OCN-010007. (001168)

169. Forward Lower Leftside Adjacent to Door, V070-391017-137, OCN-CH8080. (001169)

170. No Part Number, Body Flap Lower. (001170)

171. No Part Number, Upper Body Flap. (001171)

172. No Part Numbers, Unidentified Tile Parts. (001172)

173. No Part Number, Base Heat Shield. (001173)

174. Wing Glove, V070-191021-299. (001174)

175. Body Flap Lower, V070-395033-xxx, OCN-009204. (001175)

176. Lower Wing in Front of Main Landing Gear Door, V070-191003-xxx; OCN-008292. (001176)

177. Lower Mid Fuselage, V070-394038-126, OCN-008500. (001177)

178. Orbital Maneuvering Subsystem Pod Leading Edge, V070-396366-xxx. (001178)

179. Pillow Gap Filler, V070-396446-133. (001179)

180. Orbital Maneuvering Subsystem Pod, V070-396446-144, OCN-BW9807. (001180)

181. Main Landing Gear Door Thermal Barrier, V070-398015-035. (001181)

182. No Part Number, Miscellaneous Unidentified Parts. (001182)

183. No Part Number, Miscellaneous Tile Parts. (001183)

184. No Part Number, Upper Body Flap Tile Piece. (001184)

185. Righthand Inboard Elevon Thermal Barrier, V070-193038-216. (001185)

186. Elevon Outboard; Inboard Side Tile, V070-193017-456. (001186)

187. No Part Number, Orbital Maneuvering Subsystem Pod Leading Edge Tile Piece. (001187)

188. No Part Number, Miscellaneous Tile Pieces. (001188)

189. No Part Number, Lower Wing Tile Piece. (001189)

190. No Part Number, Lower Less Carrier Panel Tile Piece. (001190)

191. 30 Gap Filler Tile Pieces, V070-391040-098 and C175. (001191)

192. No Part Number, Unidentified Miscellaneous Tile Pieces. (001192)

193. No Part Number, Unidentified Miscellaneous Tile Pieces. (001193)

194. Lower Access Panel Tile Piece, V070-199702-033. (001194)

195. No Part Number, Main Landing Gear Door Tile Piece. (001195)

196. Lefthand Wing Tile Piece, V070-191003-287. (001196)

197. Mid-Fuselage Tile Piece, V070-394048-200. (001197)

198. Mid-Fuselage Tile Piece, V070-394044-046. (001198)

199. Aft Sidewall Tile, V070-395006-429. (001199)

200. Wing Lower Surface Tile Piece, No Part Number. (001200)

201. No Part Number, Miscellaneous Tile Piece. (001201)

202. No Part Number, Miscellaneous Tile Piece. (001202)

203. Lower Wing Tile Piece. V070-191037-xxx. (001203)

204. Main Landing Gear Door Outboard Tile Piece. V070-191105-053, S/N 068872202013330. (001204)

205. No Part Number, Miscellaneous Foam Pieces. (001205)

206. No Part Number, Miscellaneous Tile Pieces. (001206)

207. No Part Number, Aft Gap Fillers. (001207)

208. No Part Number, Miscellaneous Unidentified Tile Pieces. (001208)

209. Lower Elevon Tile, 193012—-—008944. (001209)

210. Tile Inboard Edge of Inboard Elevon, V070-193009-229. (001210)

211. Tile, V070-391040-077, Righthand Nose Landing Gear Door, OCN? G-19710. (001211)

212. Lower Carrier Plate Tile Righthand Side, V070-199702-034-H23164. (001212)

213. No Part Number, Vertical Leading Edge. (001213)

214. Lower Forward Aft of Nose Cap, V070-399415-1xx. (001214)

215. Lefthand Forward Side Wall (Under Crew Hatch), V070-391034-499. (001215)

216. Tile, V070-191106-052, G-19729. (001216)

217. No Part Number, Lower Wing/Trailing Edge. (001217)

218. Main Landing Gear Door Tile, V070-191037-088. (001218)

219. Lower Forward Fuselage, Lefthand Air Data Probe Area, V070-391036-346-009670. (001219)

220. Righthand Nose Landing Gear Door, V070-391040-078 Tile. (001220)

221. No Part Number, Orbital Maneuvering Subsystem Pod Leading Edge. (001221)

222. Unidentified Tile Parts. (001222)

223. Unidentified Tile Parts. (001223)

224. Unidentified Tile Parts. (001224)

225. Inboard Elevon Lower Tile, V070-193007-306. (001225)

226. Lower Tile, V070-191xxx-xxx. (001226)

227. Lower Wing Tile, V070-191004-0-008385. (001227)

228. Lower Wing Tile, V070-191009-136. (001228)

229. Aft Sidewall Tile, V070-395006-437, CL6659. (001229)

230. Main Landing Gear Door, V070-191121-017, G40989. (001230)

231. Inboard-Outboard Edge Elevon Tile, V070-193009-332, 009092. (001231)

232. Forward Fuselage Tile, V070-391042-044, H38232. (001232)

233. Lower Wing Tile, V070-191029-260, 009082. (001233)

234. No Part Number, Unidentified Tile. (001234)

235. Lower Wing Tile, V070-191011-168, CL6409. (001235)

236. No Part Number, Unidentified Tile Pieces. (001236)

237. Upper Wing V070-199712-037 Tile, OCN-CL1673, G2985 Tile. (001237)

238. Lower Forward—Nose Landing Gear Tile (1 each), V070-391042-060. (001238)

239. Lower Wing—136-008589, (P/N V070-191011-136 CVAS Aided) Tile (1 each). (001239)

240. Main Landing Gear Door Tile (1 each), V070-191102-033. (001240)

241. Vertical Stabilizer Tile (1 each), V070-291209-? (001241)

242. Lower Wing/Main Landing Gear Door Tile (1 each) V070-191037-019 008404, (Dash # CVAS Aided). (001242)

243. Lower Wing Tile (1 each), V070-191026-162 008715. (001243)

244. Unidentified Tile Pieces (2 each). (001244)

245. Lower Wing Glove Tile (1 each). V070-191029-231, BD579. (001245)

246. Lower Body Flap Tile (1 each), V070-395034-163, DL0145. (001246)

247. Unidentified Tile Pieces (Numerous Broken Fragments). (001247)

248. Unidentified Tile Pieces (Numerous Broken Fragments). (001248)

249. Lower Wing (1 each), V070-191008-195, 009315 (OCN CVAS Aided). (001249)

250. Nose Tile (1 each), V070-399415-118. (001250)

251. Lower Wing Tile (1 each), V070-1910011-191, 009301. (001251)

252. Lower Wing, V070-191006-010, 008052. (001252)

253. Unidentified Tile Pieces (Numerous Broken Fragments). (001253)

254. Lower Forward Fuselage (1 each), V070-391017-223, CL1800 (001254)

255. Lower Wing Tile (1 each), V070-191025-306, CL4762. (001255)

256. Vertical Stabilizer Tile (1 each), V070-291206-037, H3815. (001256)

257. Upper Body Flap Fragment (1 each), No Part Number. (001257)

258. Body Flap Tile (1 each), No Part Number. (001258)

259. Forward Fuselage (Chine and Nose) (1 each), V070-391036-067, G18912 (Location CVAS Aided). (001259)

260. Lower Wing (1 each), V070-191021-189, 009184 (Location CVAS Aided). CVAS Information Reference MR# RWNG 9-07-1505-362. (001260)

261. Unidentified Tile Pieces, (3) Broken Fragments—2 High Temperature Reusable Surface Insulation (HRSI), 1 Low Temperature Reusable Surface Insulation (LRSI). (001261)

262. Body Flap Carrier Panel Tile (1 each), No Part Number. (001262)

263. Orbital Maneuvering Subsystem Pod Tile (1 each), V070-396071-134 (OCN CVAS Aided). CVAS Information: P/N LL9070-001-TPS-3 CS1954 Pod—RV01. (001263)

264. Lower Wing Glove Tile (1 each), V070-39450-387 (CVAS (CVAS Data: V070-394504-387/G27133). (001264)

265. Body Flap Tile (1 each), No Part Number. (001265)

266. Base Heat Shield Carrier Plate Tile (1 each), No Part Number. (001266)

267. Nose Landing Gear Door (1 each) and Attached Gap Filler, V070-391041-054, G192 ______, (CVAS Data: (OCN-G19283)

268. Nose Landing Gear Door Tile—2 Pieces, No Part Number. (001268)

269. Unidentified Tile Pieces, 3 Large Pieces, 10 Small Pieces. (001269)

270. 3 Pieces Unidentified Tile, No Part Number. (001270)

271. Lefthand Inboard Wing Adjacent to Main Landing Gear Door, V070-191006-039, G37635. (001271)

272. Partial Tile (Black) Wing Glove, V070-394506-258, OCN-CM6678. (001272)

273. Miscellaneous Tile Pieces (Black), No Part Number. (001274)

274. Partial Tile (Black) Wing Glove Lower Surface, V070-394504-xxx. (001275)

275. Tile (White) Orbital Maneuvering Subsystem Pod Sidewall-Lefthand, V070-396366-028, OCN CH5112.

276. Tile (Black), No Part Number. (001276)

277. Tile (Black) Body Flap, Lower Surface, V070-395015-033, OCN DC1782. (001277)

278. (1) Tile Piece—165 Orbital Maneuvering Subsystem Pod. (001278)

279. (1) Tile Piece—175 2 each Pieces.

280. Tile, Part Number V070-394048-247 Lower Mid-Body, OCN 08801. (001280)

281. Elevon Carrier Plate Section Tile 8" × 8". (001281)

282. Tile, Part Number V070-193004-052, OCN 00835, Upper Elevon (001282)

283. Tile, Part Number V070-394048-060 Lower Mid-Body, OCN-xxxxx. (001283)

284. Tile, Part Number V070-395033 Body Flap Trailing Edge, OCN 009161. (001284)

285. Tile, V070-39-xxxxxx-057, OCN 00153, Payload Bay Door Hinge Carrier Plate. (001285)

286. Tile, Part Number V070-193004-325 Lower Elevon, OCN 008967. (001286)

287. Tile, Part Number V070-394504-255 Lower Mid-Body, OCN 008614. (001287)

288. Miscellaneous Tile Pieces—4 each. (001288)

289. Tile—Righthand Inboard Lower Elevon, Part Number V070-193003-167. (001289)

290. Tile Removed from Lower Forward Fuselage for Burn Structural Inspection. (001290)

291. Tile Removed from Lower Forward Fuselage for Burn Structural Inspection. (001291)

292. Tile Removed from Lower Forward Fuselage for Burn Structural Inspection. (001292)

293. Miscellaneous Tile Pieces. (001293)

294. Tile High Temperature Reusable Surface Insulation Lefthand Lower Forward, V070-391035-327, 008475. (001294)

295. Carrier Panel Tile; V070-199xxx. (001295)

296. Wing Trailing Edge Tile, No Part Number. (001296)

297. High Temperature Reusable Surface Insulation Tile 1 3/8" Thick, No Part Number. (001297)

298. High Temperature Reusable Surface Insulation Tile Lower Righthand Outboard Wing, V070-191025-392, 008604, (001298)

299. High Temperature Reusable Surface Insulation Tile Lower Righthand Inboard Wing, V070-191009-137, CL8064. (001299)

300. High Temperature Reusable Surface Insulation Tile Possible Orbital Maneuvering Subsystem Pod Stinger Aft End, No Part Number. (001300)

CREW MODULE COMPONENTS

1. Display Electronic Unit, P/N MC615-0008-0108, S/N 003 30V73A43. (000001)

2. Display Electronic Unit, P/N MC615-0008-0108, S/N 31 30V73A41. (000002)

3. Display Electronic Unit, P/N MC615-0008-0108, S/N 16 30V73A42. (000003)

4. Display Electronic Unit, No Part Number. 30V73A40. (000004)

5. Central Processing Unit #4, MC615-0001-0209, S/N 9. (000005)

6. Central Processing Unit #1, MC615-0001-0209, S/N 11. (000006)

7. Input/Output Processor #3, MC615-0001-0209, S/N 33. (000007)

8. Central Processing Unit #3, 6247100-25, S/N 26. (000008)

9. Central Processing Unit #2, MC615-0001-0209, S/N 19. (000009)

10. Input/Output Processor #1, MC615-0001-0313, S/N 12. (000010)

11. Input/Output Processor #2, MC615-0001-0312, S/N 9. (000011)

12. Input/Output Processor #5, MC615-0001-0312, S/N 28. (000012)

13. Mission Ascent Display System Recorder, PN ME-435-0004, S/N 1003. (000013)

14. OPS Recorder Magnetic Tape, P/N 4411900-3, S/N 1016. (000014)

15. OPS Recorder Magnetic Tape, P/N 4411900, S/N 1009. (000015)

16. Recorder Magnetic Tape, Transport Unit PL, P/N 4411700 S/N 1007. (000016)

17. Mass Memory Unit, P/N 615, S/N PD15-0202, Mfg. P/N 6239900-7. (000017)

18. Mass Memory Unit, P/N 615, S/N PD11, Mfg. P/N 6239900-7 (000018)

19. Line Replaceable Unit Avionics Bay #1, Shelf #2. No P/N. (000019)

20. Power Controller Assembly Avionics Bay #2 , V070-763340-002, A7662. (000020)

21. Line Replaceable Unit Avionics Bay #3A, Shelf No. 4 (000021)

22. Air Data Transducer,210868-3-1, S/N 7021000W318004 (000022)

23. Line Replaceable Unit Avionics Bay #3A Shelf #1 with boxes, No P/N. (000023)

24. Motor Control Assembly #2, Partial (Shelf #3 Bay #2) V07-0763620. (000024)

25. Display Drive Unit, MC409-0012-0003, S/N 0011. (00025)

26. OPS Recorder #2, Avionics Bay #2, 4411900-1. (000026)

27. Annunciator Control Assembly, MC434-0283-0003, S/N 78127 (000027)

28. Brake Skid Controller #2, MC621-0055-0004, S/N 002. (000028)

29. Display Unit, 6239800-12, S/N ______. (000029)
30. DC Current Sensor, ME449-0152-0024, S/N 016. (000030)
31. Mission Ascent Display System Control Module & Shelf. V408-763220-001, AC-2527. (000031)
32. Air data Transducer #2, Avionics Bay #2, P/N MC409-0006, S/N 702 000W0310003. (000032)
33. Motor Control Assembly #1, Avionics Bay #2, V070-763600. (00033)
34. Line Replaceable Unit Black Box, Partial. (000034)
35. Electrical Package 10 Ch. MC452-0124-0009 & V070-002, S/N B35594 (INV). (000035)
36. DC Current Sensor. ME449-0152-0024, S/N 26. (000036)
37. Input/Output Processor. Spare Avionics Bay 3B MC615-S/N 27. (000037)
38. Central Processing Unit #5, MC615-0001-0207, S/N 27. (000038)
39. Central Processing Unit #6, MC615-0001-0209, S/N 12. (000039)
40. Light Assembly, Partial. MC434-0068-0030, S/N 526. (000040)
41. Transformer, Partial, F7 Panel. Me446-0035-5011. (000041)
42. Backup Flight Controller, MC615-0023-0004, SN 94756-TJ0010. (000042)
43. Rudder Pedal Transducer Assembly, MC621-0043-3440, S/N CG1072-AB01. (000043)
44. Panel, 0-14 Partial V070-732194-004, C49612. (000044)
45. Display Driver Unit, 30V73A3, MC409-0023-0003, S/N 13. (000045)
46. Light Dimmer, MC459-00004-0001, S/N 17803. (000046)
47. Light Dimmers, with structure, 4 Ea. MC459-0004-0001 S/N's 68034, 98263, 19623, 68032. (000047)
48. Display Driver Unit, MC40900023-0003, S/N 16. (000048)
49. Line Replaceable Units, 2 Ea., Avionics Bay #2 Shelf with 2 Boxes. MC450-0055-0011, S/N 0002, Hybrid Load-LCA #2; MC615-0004-5710 S/N 009080075, MDM PF2. (000049)
50. Annunciator Control Assembly #4, MC434-0283-0002. (000050)
51. Decoder, MC409-0017-0006, S/N 024. (000051)
52. Multiplexer/Demultiplexer, partial. MC615-0004-6510. (000052)
53. Smoke Detector, MC431-0127-1103, S/N 21. (000053)
54. Computer Interface Conditioning Unit. MC 434-0080-001,S/N 128013. (000054)
55. Line Replaceable Unit Avionics Bay #2 Shelf, 5 Ea. (000055)
56. Audio Terminal Unit -30V74A102, MC409-0005-0012, S/N 002 (000056)
57. Panel ML 86B, partial. V070-730382-001, 80V73A130. (000057)
58. Line Replaceable-Units Avionics Bay 3B Shelf (2 Ea.) Black Boxes. MC40900025- S/N 103, 85V74A18; MC409-0096-0012, S/N 113. (000058)
59. Air Data Transducer, Avionics Bay #1, V070-703058-002 J07628. (000059)
60. Master Timing Unit. MC456-0051-0004. (000060)
61. Water Pumps with Structure. (2 Ea.) MC621-0008-0455, S/N 0005, V61H2612A; MC621-0008-0456, S/N 0003. (000061)
62. Line Replaceable Units Avionics Bay, 2 Shelf MC478-0105-0001, S/N 305, 82V74A10, 81V74A6. (000062)
63. Avionics Bay #2 Shelf with 3 Boxes. (000063)
64. Signal Conditioner, Avionics Bay Forward. (000064)
65. Line Replaceable Unit Partial, No P/N. (000065)
66. Star Tracker, MC431-0128-0013, S/N 0010. (000066)
67. Tactical Air Navigation #1 Receiving Transmitter 81V74A26, MC409-0014-. (000067)
66. Tactical Air Navigation #3 Receiving Transmitter MC409-0014-00006. (000068)
69. Inverter Distributor Controller #1, 81V76A35 V070-763320-003, J43175. (000069)
70. Power Control Assembly #1, 81V76A22, V070-763320-003 J43175. (000070)
71. Inverters, attached to shelf. 3 Ea. (000071)
72. Line Replaceable Units Avionics Bay Shelf. (000072)
73. Line Replaceable Units Avionics Bay #3, Shelf #2. (000073)
74. Line Replaceable Units Avionics Bay #3, Shelf #3. (000074)
75. Line Replaceable Unit, No P/N. Interface Unit. (000075)
76. Line Replaceable Unit, partial. No P/N, (000076)
77. Radar Altimeter #2, MC409-0015-0004, S/N 017 82V74A16. (000077)
78. Electrical Package—10 Channel. MC452-0124-0009. (000078)
79. Smoke Detector, V62Q0628A, MC431-0127-0103, S/N 33. (000079)
80. Interface Unit, 257212-55, S/N 203. (000080)
81. Audio Terminal Unit #2, MC409-0005-0012, 30V74A104. (000081)
82. Line Replaceable Unit, No P/N. (000082)
83. Audio Unit, MC ________ 0005-024. (000083)
84. Panel Assembly, R-4 (000084)
85. Panel Assembly, R-1 (000085)
86. Panel Assembly, R-2 (000086)
87. Panel Assembly, 0-8 Partial. (000087)
88. Panel Oxygen, C-7. (000088)
89. Panel Assembly, C-3. (000089)
90. Panel Assembly, 0-6 Partial. (000090)
91. Panel Assembly, F-9. (000091)
92. Panel Assembly R-12 Partial. (000092)
93. Panel Assembly, R-12 Partial. (000093)
94. Panel Assembly, A-11 (000094)
95. Panel Assembly, A-11 Partial. 2 Pieces, (000095)
96. Panel Assembly, A-14 Partial. (000096)
97. Panel Assembly, A-14—Partial. (000097)
98. Panel Assembly, L-11 (IUS Control). (000098)
99. Standard Switch Panel, L-12 (000099)
100. Audio Terminal Unit with Mid Deck Overhead Panel. MC409-0005-0012, 80V73A120A1. (000100)
101. Translational Hand Control, MC621-0043-3140, S/N 0006. (000101)
102. Panel, R-15—Partial, 32V73A15. (000102)
103. Panel Assembly, A-12. (000103)
104. Panel Assembly, A-8—Partial. (000104)
105. Panel Assembly-Comm Interface Unit Auxiliary. (000105)
106. Panel Assembly Audio Main Switch. A10A2511. (000106)
107. Panel Assembly-Keyboard/CRT. (000107)
108. Panel Assembly, Partial. A1. (000108)
109. Mid Deck Floor Section Avionics Bay #2. (000109)
110. Mid Deck Avionics Bay 2 Floor Section. (000110)
111. Mid Deck Volume F Access Door. MD73N. (000111)
112. Mid Deck Floor Seat Support. (000112)
113. Mid Deck Floor Structure. XCM 237 to XCM 259. (000113)
114. Mid Deck Floor Structure over Environmental Life Support System Bay. (000114)
115. Mid Deck Environmental Control Life Support Avionics Bay 1 floor section (000115)
116. LIOH Canister Access Door. MD52C. (000116)
117. Mid Deck Floor forward of waste management with Structure. (000117)
118. Mid Deck floor Environmental Control Life System Bay, XCM 237.861 to 259.320. (000118)
119. Mid Deck, R/H Aft. Floor structure Outboard. (000119)
120. Main Tunnel Hatch, Mid Deck, 3 Pieces. -1 to -2. (000120)
121. Main Hatch, Mid Deck 5 pieces. -1 to -4. (000121)
122. Waste Management, Mid Deck, L/H Side, 6 pieces. -1 to -5. (000122)
123. Mid Deck Floor Section. (000123)
124. Mid Deck Floor Structure with ducting. (000124)
125. Mid Deck L/H Side Bay 3B structure. (000125)

126. Mid Deck Sidewall structure. (000126)

127. Panel Assembly, A-7, Partial. V408-731500-002, AC1621 36V73A7A2&A. (000127)

128. Line Replaceable Unit, Partial, No P/N. (000127)

129. Panel Assembly, R-15 Partial. (000129)

130. Panel 0-1 possible Meter, No P/N 33V73A1M10. (000130)

131. Thumb Wheel Assembly, No P/N. (000131)

132. Flight Deck, Partial, No P/N. (000132)

133. Panel, Aft Flight Deck, Partial, No P/N. (000133)

134. Panel Assembly, L-1 31V73A1A2R1. (000134)

135. Panel Assembly, A7-A5, Partial with structure. (000135)

136. Panel Assembly, R-16, Partial. V070-339604-001. (000136)

137. Panel Assembly, L-2 31V73A2A1. (000137)

138. Panel Assembly, Partial, F-6, (34V73A6A8. (000138)

139. Speed Brake Thrust Controller. MC621-0043-3240, S/N 006. (000139)

140. Panel, F-7 with CRT #2 & 3. (000140)

141. Panel, F-8 Assembly, Partial. 34V73A8A5. (000141)

142. Meter, Flight Deck Area, No P/N. (000142)

143. Attitude Direction Indicator, No P/N. 34V73A6A3. (000143)

144. Communication Interface Unit. Panel Assembly. (000144)

145. Mid Deck floor L/H Forward Outboard Edge. (000145)

146. Mid Deck Avionics Bay 3A Vertical Wall Inboard. (000146)

147. Mid Deck Airlock part. Assembly of 18 Pieces. -17. (000147)

148. Mid Deck Structure with Nitrogen Lines. (000148)

149. Mid Deck Main Hatch Atenuator & Mount. (000149)

150. Fan Duct manifold for Avionics Bay B, Avionics Bay A. Mid Deck (000150)

151. Air Duct for Avionics Bay B and Bay A. Mid Deck. (000151)

152. Fan Duct Manifold for Avionics Bay A & B. Mid Deck. 1 Ea. (000152)

153. C/M Mid Deck Air Duct with structure. (000153)

154. Environmental Control Life Support System, 14" Mid Deck. (000154)

155. Flight Deck Mid Deck floor & sidewall R/H side. XCM 355, XO 531 ZO 419. (000155)

156. Mid Deck Outer Skin structure, location unknown. (000156)

157. Mid Deck floor structure. XCM 189 R/H. (000157)

158. Mid Deck Forward Lower Bulkhead R/H. (000158)

159. Mid Deck Avionics Bay Vertical Support. (000159)

160. Mid Deck lower R/H Crew Module Skin XCM 230. (000160)

161. Mid Deck Avionics Bay 1 & 2 Vertical Wall. (000161)

162. Mid Deck Lower Forward Bulkhead. (000162)

163. Panel Assembly, F-8, Hydraulic Pressure & Quantity. (000163)

164. Thumb Wheel Assembly (triple) No P/N. (000164)

165. Panel Parts, Flight Deck, miscellaneous. No I.D. (000165)

166. Emergency Lighting. Partial Panel. V070-731360-003. B16980. (000166)

167. Panel Assembly, R13U 32V73A12A1. (000167)

168. Panel Assembly, C2, V070-731330-001, B38919 35V73A1A2W1. (000168)

169. Panel, A7L Partial (Payload Bay Door Floods). (000169)

170. Panel Assembly, A6-A1, 36V73A6A1. (000170)

171. Circuit Breaker Panel. Partial. No I.D. (000171)

172. Panel Assembly, 0-8 Partial. No I.D. (000172)

173. Panel, 0-7 Partial. Reaction Control System Driver Switch. (000173)

174. Circuit Breaker Panel Assembly, L-4 (Cabin Air, H_2O. (000174)

175. Video Tape Recorder Unit. SED16101760-301, S/N 1004. (000175)

176. Rotational Hand Controller with structure. (000176)

177. Rudder Pedal Assembly, L/H. V070-573003-005. (000177)

178. Rotational Hand Controller, L/H. related P/N V070-732063-001, F73876. (000178)

179. Line Replaceable Unit. Partial. No I.D. (000179)

180. Line Replaceable Unit. Partial. No I.D. (000180)

181. Flight Deck Floor Section with N_2O_2 Panel. (000181)

182. Flight Deck Floor Section. XO 546,YO-61. (000182)

183. Flight Deck Floor Section, XO 574, YO +48. (000183)

184. Flight Deck Floor Section with seat mount. (000184)

185. Flight Deck Floor Section, probable Seat #3 Mount. (000185)

186. Flight Deck Floor Section, with one R/H Seat mount. (000186)

187. Flight Deck Floor Section with one R/H Seat mount. (000187)

188. Flight Deck Floor Section with Display Electronic #2 & #4 Mount. (000188)

189. Structure Angle. V070-338572-001, C50391. (000189)

190. Flight Deck Floor Section with Display Driver Unit #1 & 2 Mount. (000190)

191. Flight Deck Floor Section. (000191)

192. Flight Deck Floor beam with rudder pedal components. (000192)

193. Rudder Pedal Bungee & Structure L/H. (000193)

194. Flight Deck Floor Section with Display Electronic #2 & #4 Mounts. (000194)

195. Line Replaceable Unit Support Structure. No I.D. (000195)

196. Flight Deck Floor Section with L/H Inboard Seat Mount. (000196)

197. Flight Deck Floor Section with Display Electronic #2 & #4 Mounts. (000197)

198. Floor Section, Mid or Flight Deck. (000198)

199. Support structure with dowel pins. V070-335194-002 B39226. (000199)

200. Band Clamp. ME277-0015-1500. (000200)

201. Feedthru Plate – Dyna Tube. V070-332825-004. (000201)

202. Coax Cable Section structure. (80V70A10). No P/N. (000202)

203. Tube Assembly, partial. No P/N. (90 psi water). (000203)

204. Channel, Aluminum, 9" long. V070-338504-002, B79529-1 (000204)

205. Duct, Cooling, V070-612875-002. (000205)

206. Airlook "A" Hatch Window Frame. V070-331440-001. (000206)

207. Partial Pressure O_2 Sensors, System #1 & 2. (000207)

208. Line Replaceable Unit, Partial. No P/N. (000208)

209. Multiple Headset Adapter, MC409-0005-0300, S/N 0005. (000209)

210. Line Replaceable Unit-With Cooling Duct, Rear C27059. (000210)

211. Closeout Panel, Aft Wall Waste Collection System Compartment. (000211)

212. Pressure Bulkhead Electrical Feed Thru-. V070-793283-B79961. (000212)

213. Channel, Aluminum, 36" long. V070-334886-004, C00148. (000213)

214. Electrical Feed Thru with 2 Connections. 36V73A8A1P2. (000214)

215. Brake Controller Transducer. MC621-0055-0015, S/N 225792. (000215)

216. Air Duct, Cooling, Electrical Unit. V070-613404-008. (000216)

217. Structure, Aluminum, Milled. 7" × 23". V070-333443-001. (000217)

218. Channel, Aluminum, 27" × 19". #DD39110107-001. (000218)

219. Vented Panel, Partial. V627-335180-001, BA4579. (000219)

220. Mid or Flight Deck Floor Section. No P/N. 20" × 27". (000220)

221. Structure, Aluminum, 6" long. Ref. V070-339719-02, AW4781. (000221)

222. Hand Hold Support, No P/N. (000222)

223. Line Replaceable Unit, Air Outlet, No P/N. (000223)

224. Duct, Cooling, with Flex Coupling. 5" × 1½" Dia. (000224)

225. Panel, Flight Deck, partial. 9" long. (000225)

226. Structure, Aluminum, No P/N. XO 535, YO + 39, ZO 135. (000226)

227. Support, Aluminum, 16" × 2½". V070-339230-004. (000227)

228. Channel, Aluminum, 21" × 2". Ref. V070-334110-006. (000228)

229. Inter Deck Access. Fiberglass Fairing. Ref. V070-337829-001, B40239. (000229)

230. Retainer, 8" long, Partial. V070-398411-002. (000230)

231. Fiberglass Support, V070-553092-002, 36" × 1 3/4". (000231)

232. Line Replaceable Unit Mount Rear—Air Cooled. Ref. V070-613733-002. (000232)

233. Beam, Aluminum, 4" × 72" (576 Bulkhead). (000233)

234. Panel, Aluminum, No P/N. (000234)

235. Structure parts. Miscellaneous. (000235)

236. Brackets & tubs. Miscellaneous. (000236)

237. Brackets & structure parts. Miscellaneous. (000237)

238. Stringer & structure parts. Miscellaneous. (000238)

239. Structure Parts. Miscellaneous. (000239)

240. Tubing parts. Miscellaneous. (000240)

241. Structural parts. Line Replaceable Unit Handle, Miscellaneous. (000241)

242. Structural parts. Miscellaneous. (000242)

243. Panel Parts, Switch, Miscellaneous. (000243)

244. P-C Boards Parts. Miscellaneous. (000244)

245. Structure & Honeycomb. Miscellaneous. (000245)

246. Blanket Gold. Miscellaneous. (000246)

247. Line Replaceable Unit Part, Miscellaneous. V070-703741-001, OCN C50131. (000247)

248. Line Replaceable Unit; Miscellaneous. V070-703756-001, OCN C47522. (000248)

249. Inertial Measurement Unit, Slide Rail. V070-703719-001, C02050. (000249)

250. Line Replaceable Unit End. V070-731076-003. (000250)

251. Line Replaceable Unit, Partial. V070-732454-003, OCN 19369. (000251)

252. A8 Control Panel. Partial (000252)

253. Star Tracker. Partial. (000253)

254. Line Replaceable Unit. Partial. MD417-0118-0001, F56472. (000254)

255. Star Tracker. Partial. (000255)

256. Line Replaceable Unit Cover. Partial. 964927. (000256)

257. Speaker/Mid Deck. DMR 46265. (000257)

258. Light Dimmers. 3 Ea. 30V73A150, V070-3390-34-001, OCN 829433. (000258)

259. Internal Volume Assembly Rail. V623-661106-J55810. (000259)

260. Structure Assembly, V070-333235-002, E48927. (000260)

261. Structure Assembly, Outer Pressure. (000261)

262. Fiberglass Closeout, R/H V070-613117-001, F85836. (000262)

263. Inertial Measurement Unit, Line Replaceable Unit/possible. (000263)

264. Line Replaceable Unit, Partial. No P/N. (000264)

265. Cabin Fan Manifold. (000265)

266. Part, Possible Payload. V070-331443-001. (000266)

267. Water Tank End. Partial. (000267)

268. Airlock-Hatch Hinge Set structure. (000268)

269. Line Replaceable Unit, Rear Mount End. V070-70377-0011, B475206. (000269)

270. Panel, MO-13Q, Partial. 80V73A81. (000270)

271. TV Monitor Aft Flight Deck Area, 2 Ea. (000271)

272. Panel Assembly, AW8A (000272)

273. Panel, Coolant Loop #2. Partial. (000273)

274. Bungee— Partial. V070-573055-001. (000274)

275. Airlock Storage Rack—Extra Vehicular Activity Ref. SV772201-2, S/N INR02. (000275)

276. Panel Assembly, 0-7 (000276)

277. Rudder Pedal Support & Associated Hardware. (000277)

278. Airlock Storage Rack—Extra Vehicular Activity Suit, (000278)

279. Water Tank, Lower. Mount. V070-623062-002, E50429. (000279)

280. Water Tank, Environmental Control Life Support Bay, Partial. (000280)

281. Panal with Electronic Box. Partial. SED18100070301. (0000281)

282. Structure, Pressure Vessel, Upper. Ref. V070-732155 __________. (000282)

283. Panel, Partial. 33V73A15,-015. (000283)

284. Airlock Pressure Equalizer Valve, "A" or "B" Hatch. (000284)

285. Structure, Pressure Vessel L/H Side. (000285)

286. Structure, Pressure Vessel, Upper. (000286)

287. Structure, Pressure Vessel, W1 or W6 Area. (000287)

288. Panel, Partial. L-14 (000288)

289. Line Replaceable Unit. Partial. No P/N. (000289)

290. Annunciator Control Assembly #5, MC434-0283-0003, 30V73A20, S/N 57808. (000290)

291. Smoke Detector with air duct. (000291)

292. Attitude Direction Indicator. No P/N-No S/N. (000292)

293. Line Replaceable Unit. Partial. No P/N. (000293)

294. Thumb Wheel, MC452-134-XX60. (000294)

295. Structure, Outer Pressure Vessel 52" × 8". (000295)

296. Floor panel Forward, V070-335105-001, J06515. (000296)

297. Closeout—V070-339685-001, E47241. (000297)

298. Panel, Partial. 34V73A2-F2. (000298)

299. Structure, Probable Aft Bulkhead. (000299)

300. Structure, Pressure Vessel. V070-331013-010. (000300)

301. Feed Thru with structure. No P/N. (000301)

302. Structure, Pressure Vessel, 9" × 32". (000302)

303. Airlock Ceiling or floor section. V075-650618-001. J16316. (000303)

304. Filter Manifold- Avionics Bay or Cabin. (000304)

305. Structure, Primary, 50" × 22". (000305)

306. Structure, Pressure Vessel. (000306)

307. Structure, Pressure Vessel—W1 or W6. Ref. 80V77W1TB8. (000307)

308. Structure, Pressure Vessel, No P/N. Irregular shape. (000308)

309. Stiffener, Outer Sidewall. (000309)

310. Rib Section "T" Shape, 61" × 4¼". (000310)

311. Structure, Internal—10" × 16", No P/N. (000311)

312. Structure, "T" Shape. (000312)

313. Cover, Aluminum. V070-334558-001, F31706. (000313)

314. Channel, Internal aluminum. (000314)

315. Face Sheet, aluminum. previously hot bonded. (000315)

316. Kick Panel—No P/N. Partial. (000316)

317. Structure, Pressure Vessel-Upper. No P/N. (000317)

316. Structure, Internal-Milled Waffle Pattern. No P/N. (000318)

319. Structure, Milled—Chemical Film Finish. (000319)

320. Structure, Internal. No I.D. (000320)

321. Airlock Aluminum Honeycomb Section No P/N. (000321)

322. Flight Deck Floor Section-behind L/seat. No P/N. (000322)

323. Line Replaceable Unit Cooling Duct, Flexible. No P/N. (000323)

324. Structure, Pressure Vessel, L/H Bay 1. Ref. 81V70A5. (000324)
325. Structure, 13" × 1½", No I.D. (000325)
326. Structure, Crew Module "T" Shape, 15" × 1¼". (000326)
327. Structure "C" Channel—Forward Overhead Console. (000327)
328. Structure, Interior. No I.D. (000328)
329. Honeycomb/Aluminum. Waste Collection System (000329)
330. Panel. No I.D. (000330)
331. Structure, Milled—Low Reflective Paint. (000331)
332. Altitude Vertical Velocity Indicator. (000332)
333. Tube Assembly, Joint #BSGL-081, 90 psi water. (000333)
334. Toggle Switch, No I.D. (000334)
335. Closeout Panel, Flight Deck, L16 or L17. (000335)
336. Structure, Aluminum Channel. SDD39110207. (000336)
337. Floor Section—Mid or Flight Deck. (000337)
338. Electric Component, V514-00210-11, S/N DBH0009. (000338)
339. Sidewall-Airlock Wall. 22" × 37". (000339)
340. Closeout Panel, V075-333081-004, E49505. (000340)
341. Structure & Tubing. Aluminum. Low Reflective Paint. V070-333345-005. (000341)
342. Structure, Aluminum, Crew Module, with Ground. (000342)
343. Channel & Honeycomb. Aluminum. No I.D. (000343)
344. Channel. Aluminum.V070-333814-005, S/N B42565. (000344)
345. Line Replaceable Unit. Partial. No P/N. (000345)
346. Structure, Aluminum. Low Reflective Paint one side. (000346)
347. Structure, Pressure Vessel. No I.D. (000347)
348. Cooling Duct, Flexible, No I.D. (000348)
349. Rib Section. Aluminum with Tubing. (000349)
350. Structure, Possible Forward Bulkhead. (000350)
351. O-Ring Section, 31" long × 9/32" diameter. (000351)
352. Angle, Aluminum. 13" Long. (000352)
353. Structure, Aluminum with Cabin Light Switch. (000353)
354. Tube Assemblies-Coolant. Miscellaneous. (000354)
355. Gold Blankets. Miscellaneous. (000355)
356. Threaded Mount with Honeycomb. (000356)
357. P/C Boards. Miscellaneous. (000357)
358. Hinge, Aluminum. 13" long. No I.D. (000358)
359. Floor Panel, Below Forward Overhead Seat. (000359)
360. Pressure Vessel. No I.D. (000360)
361. Payload Timing Buffer & Structure. Reference Designator Connector 38P77W731. (000361)
362. Flex Line, ½", 15" long. (000362)
363. Structure, 3 pieces of miscellaneous. (000363)
364. Window Support, Forward. 39" long. (000364).
365. Windows #4, 5, & 6, Flight Deck. R/H. (000365)
366. Line Replaceable Unit, Partial. No P/N. (000366)
367. Structure, Pressure Vessel. (000367)
368. Wire Tray Section Forward Overhead L/H Side Aft. (000368)
369. Display/Switch Panel pieces. Miscellaneous (000369)
370. Structure, Pressure Vessel Section—10" × 50". (000370)
371. Structure, Pressure Vessel Section—18" × 53". (000371)
372. Structure, Pressure Vessel Section—18" × 32". (000372)
373. Structure, Pressure Vessel Section—11" × 20". (000373)
374. Structure, Pressure Vessel Section—22" × 63". (000374)
375. Structure, Pressure Vessel Section—18" × 20". (000375)
376. Structure, Pressure Vessel Section—11" × 18". (000376)
377. Structure, Pressure Vessel Section—21" × 42". (000377)
378. Feed Thru—Electric—82V70A4. (000378)
379. Structure, Pressure Vessel, Environmental Control Support System Bay, 19" × 33". (000379)
380. Sidewall Stiffener, 3½" × 46". (000380)
381. Structure, Pressure Vessel, Environmental Control Support System Bay, 9" × 10". (000381)
382. Structure, Pressure Vessel, Environmental Control Support System Bay, 14" × 29". (000382)
383. Structure, Pressure Vessel, Environmental Control Support System Bay, 61" × 73". (000383)
384. Structure, Pressure Vessel, Environmental Control Support System Bay, 80" × 72". (000384)
385. Structure, Pressure Vessel, Sidewall. 21" × 30". (000385)
386. Structure, Pressure Vessel, Environmental Control Life Support System Bay, 7" × 33". (000386)
387. M010W Panel Guard, Ceiling Waste Collection System. (000387)
388. Wire Support, Aluminum. V070-336547-007. E69025. (000388)
389. Structure, Aluminum Section. (Ref. V070-336006-005). (000389)
390. Feed Thru—4/12" diameter. (000390)
391. Panel, Aluminum. 2 pieces, No I.D. (000391)
392. Sidewall Stiffener, 3½" × 45". (000392)
393. Channel with Tubing. Aluminum. V070-338510-001. (000393)
394. Frame, Aluminum. No I.D. 12" × 21". (000394)
395. Panel, Aluminum. (35V73A3A3) with wiring. (000395)
396. Panel, Aluminum. 9" × 20". (000396)
397. Line Replaceable Unit, Cooling Duct, V408-413251-001.A05279. (000397)
398. Structure, Aluminum. (Ref. MR-STR-9-06-1156). (000398)
399. Channel, Aluminum. SED 39110201-301, S/N 1008. (000399)
400. Line Replaceable Unit Mount with Pusher Bolts, V070-703759-001,J00341. (000400)
401. Support, Aluminum. V070-336405-009, B23288. (000401)
402. Gusset, V070-336268-001, B46001. (000402)
403. Panel. Aluminum. V070-339539-002, C47471. (000403)
404. "I" Beam. Aluminum. (MR/DR 3898-000M). (000404)
405. Channel, Aluminum. V070-339630-001, F73874. (000405)
406. "I" Beam, Aluminum. V070-339602-001, C47257. (000406)
407. Feed Thru, 6" diameter, No. I.D. (000407)
408. Actuator, A1047A127. (000408)
409. Channel, Aluminum. (C1552). (000409)
410. Structure, Aluminum. No I.D., 5¾" × 4½". (000410)
411. Structure, Aluminum, with Spherical Fitting. (000411)
412. Line Support, V070-383137-004, J34121. (000412)
413. Rib Section, Aluminum. 1" × 48". No I.D. (000413)
414. Skin/Honeycomb, Aluminum. 81V72A11. (000414)
415. Avionics Bay #1 Fans & Manifold. Ref. 5002587A. (000415)
416. Avionics Bay #3 Fans & Manifold. Ref. SV755525-3, (000416)
417. Avionics Bay #2 Fans & Manifold. Ref. SV755525-3, S/N I8803. (000417)
418. Light Assembly. No I.D. (000418)
419. Structure, Flight Deck, with Wire Harness. (000419)
420. Channel. Aluminum. V070-338505-002, B79531. (000420)
421. Light Assembly, V070-337701-001. (000421)
422. Light Assembly, V070-337701-007, C37454. (000422)
423. Light Assembly Lens, No P/N. (000423)
424. Structure with wire harness, Avionics Bay 1. (000424)
425. Structure, Aluminum. No I.D. (000425)
426. Water Tank, Environmental Control Life Support Bay. (000426)
427. Water Tank, Outlet End. (000427)
428. Water Tank, Partial, End. (000428)
429. Water Tank, Baffle Partial. (000429)
430. Closeout, Avionics Bay 3A. 2 pieces. (000430)
431. Sidewall Stiffener, R/H Mid Deck. (000431)
432. Heat Exchanger with structure. (000432)

433. Volume, MD 73N. Partial. V070-336701-002. N15370. (000433)

434. MD76C, Partial. V070-336653-001, C41959. (000434)

435. MD80R, Partial. (000435)

436. MD23R, Partial. V070-336751-007, E71383. (000436)

437. Access Door, Avionics Bay #3B, No P/N. (000437)

438. Volume "A", Partial, V603-660760-001, AC0723. (000438)

439. Line Replaceable Unit, Partial. V070-763605-001, F63562. (000439)

440. Support, Aluminum. V070-793628-001, F19402. (000440)

441. Heat Exchanger with Structure. Ref. V070-336852-008. B93804. (000441)

442. Solenoid Valve, 45790-022, Ref. V070-623506-001. (000442)

443. Channel, Aluminum. Milled. No P/N. (000443)

444. Channel, Aluminum. Milled. No P/N. (000444)

445. Line Replaceable Unit Mount, V070-703763-004. (000445)

446. Line Replaceable Unit Mount, V070-703759, C47113. (000446)

447. Feed Thru, Electric, 80V70M68J101. (000447)

448. Feed Thru, Electric Coax, 85V74W605J605. (000448)

449. Lens Ceiling Panel Pieces. Miscellaneous. (000449)

450. Line Replaceable Unit. Partial. No P/N. (000450)

451. Line Replaceable Unit Mounting Rail, V070-703719-001. C02045. (000451)

452. Control Panel. (Potable Water Tank A & B), Partial. (000452)

453. Structure, Avionics Bay #1. No P/N. (81E9). (000453)

454. Flex Hose Assemblies, ME271-0091-1123, S/N 16519-004. (000454)

455. Gold Blankets. Miscellaneous. (000455)

456. Air Duct. Partial. 5" diameter. (000456)

457. Shroud, Cooling, Partial. No P/N. (000457)

458. Lines, Coolant. ⅜" diameter, V070-613869-012. (000458)

459 Lines, Coolant. Ref. V070-336277-002, B19419. (000459)

460. Lines, Water. V070-613868-051, B84829. (000460)

461. Lines, Coolant. V070-613868-054, B84831. (000461)

462. Tube Assemblies, Gang Run Section. Ref. V070-334970-002 B42579. (000462)

463. Tube Assemblies. Gang Run Section. (000463)

464. Tube Assemblies, 1/2" diameter. Ref. V070-336336-003. B29426. (000464)

465. Tube Assemblies, with structure and wiring. Ref. 90V62A11J1. (000465)

466. Lines, Coolant; with Outer Pressure Vessel Structure. V070-613873-014, C38661. (000466)

467. Tube Assembly, Flexible. ME271-0091-1133, S/N 16519. (000467)

468. Lines, Coolant. V070-613868-034, B84814. (000468)

469. Oxygen Tube Assembly with Structure. V070-613146-024. (000469)

470. Tube Assemblies, 1/2" diameter, V070-613869-014, B84853. (000470)

471. Tube Assemblies, 1/2" diameter, V070-612869-049, B84827. (000471)

472. Tube Assembly, ½" diameter, V070-613868-026. B84806. (000472)

473. Tube Assemblies, ⅜" diameter. No P/N. (000473)

474. Tube Assemblies, ⅜" diameter. V070-613066-030. C34551. (000474)

475. Tube Assemblies, Coolant, ⅜". V070-613066-019, C42581. (000475)

476. Tube Assembly, Nitrogen, ¼". V070-623204-050. C51529 (000476)

477. Insulation Blankets, Avionics Bay #3 Cover. 2 Ea. (000477)

478. Sheet Metal, Aluminum. Possible Glare Shield Forward Overhead. No P/N. (000478)

479. Structure, Aluminum. Milled. No P/N. (000479)

480. Pressure Vessel, 3/16" thick. (000480)

481. Wire harness over. No P/N. (000481)

482. Intercoastal. Aluminum. V075-333123-001, F69127. (000482)

483. Support. Aluminum. No P/N. 30" long. (000483)

484. Rib, Aluminum. Partial, 36" long. (000484)

485. Tube Assembly, No I.D. Miscellaneous. (000485)

486. Aluminum Closeout, with control panel. Partial. (000486)

487. Window Frame Outer with Carrier Panels. (000487)

488. Window Frame Outer with Carrier Panel. (000488)

489. Window Structure with Purge Boot, partial. (000489)

490. Window Structure, Pressure Vessel. (000490)

491. Window Structure, Pressure Vessel with tubing. (000491)

492. Window Structure with Carrier Panels. (000492)

493. Window Structure with Carrier Panels. (000493)

494. Window Structure with Carrier Panels. (000494)

495. Window Structure with Carrier Panels. (000495)

496. Window Structure with Carrier Panels. (000496)

497. Window Structure, Pressure Vessel. (000497)

498. Window Frame Components. Miscellaneous. (000498)

499. Translational Hand Controller, Aft Overhead. No P/N. (000499)

500. ML86B Circuit Breaker Panel, Partial. (000500)

501. Switch Panel, Partial. (000501)

502. Switch Panel, Partial. -19; V070-732240-001. (000502)

503. Line Replaceable Unit. Partial. 36V73A8A1. (000503)

504. Rotational Hand Controller, No P/N. (000504)

505. Cover Assembly, V070-339158, Partial. (000505)

506. Line Replaceable Unit Cooling Duct. 1½". (000506)

507. Forward Overhead Closeout with Vent Screen. Partial. (000507)

508. Structure, Pressure Vessel, No I.D. (000508)

509. Recorder Cooling Shroud, No I.D. (000509)

510. Panel, Standard Switch with outer structure. (000510)

511. Mid Deck Floor Section, with electrical Feed Thru. (000511)

512. Air Duct with cabin, V070-612618-001, A76661. (000512)

513. L/H Wall Waste Collection System, V669-000661-001, 10628-HF6023. (000513)

514. Cooling Unit Filter Assembly with aluminum airlock wall section. SV767709-9-15, S/N 014. (000514)

515. Rotational Hand Controller handle, Partial. (000515)

516. W-10 Closeout, Partial. (000516)

517. Line Replaceable Unit, Partial. No I.D. (000517)

518. Housing, Possible Pressure Valve. Partial. (000518)

519. Purge Boot, No P/N. Possible Side Hatch area, Partial. (000519)

520. Blanket—V070-365413-001, J19685. (000520)

521. Glare Shield Area. Sheet Metal. (000521)

522. Access Door, No P/N. Flight Deck or Bay 3B. (000522)

523. Debris Net, C/M Mid Deck. No P/N. (000523)

524. Line Replaceable Unit Mount, Rear, Air Cooled. V070-703740-001, C07199. (000524)

525. Outer Structure, Lower, 9' × 9'6", No P/N. (000525)

526. Tube Assemblies, V070-613872-045, B84986. (000526)

527. Outer Structure, 26" × 15". No P/N. (000527)

528. Avionics Bay Shelf. Partial. No I.D. (000528)

529. Airlock Floor Section, 12" × 5". (000529)

530. X_o 576.0 Bulkhead Section, 17' × 12'. (000530)

531. X_o 576.0 Bulkhead Section, 78" × 30". (000531)

532. X_o 576.0 Bulkhead Section, 96" × 55". (000532)

533. X_o 576.0 Bulkhead Section, 18" × 17". (000533)

534. X_o 576.0 Bulkhead Section, 25" × 12". (000534)

535. Xo 576.0 Bulkhead Section, 56" × 2½". (000535)

536. X_o 576.0 Bulkhead Section, 101" × 44". (000536)

537. Upper Forward Fuselage Section, 72" × 23". (000537)

538. R/H Forward Payload Bay Sill Section with Payload Door Section. 96" × 56". (000538)

539. Extra Vehicular Activity HandHold, 12" long from 576.0 Bulkhead. (000539)

540. X_o 576.0 bulkhead Section, Y_o-52. Ref. V070-337570-002. (000540)

541. Extra Vehicular Activity HandHold X_o 576.0 Bulkhead V070-650758-004. (000541)

542. Extra Vehicular Activity HandHold X_o 576.0 Bulkhead V070-650758-004. (000542)

543. Extra Vehicular Activity HandHold X_o 576.0 Bulkhead V070-650755-005, C37235. (000543)

544. Connector Box, 30V70A6, X_o 576.0 Bulkhead, L/H. (000544)

545. Connector Box, 30V70A1, X_o 576.0 Bulkhead, L/H. (000545)

546. Extra Vehicular Activity HandHold X_o 576.0 Bulkhead V070 650755-004, J00108. (000546)

547. Insulation Blanket, White, X_o 576.0 Bulkhead. (000547)

548. X_o 576.0 Bulkhead Structure with Payload, L/H (000548)

549. X_o 576.0 Bulkhead Structure, 66" × 3". (000549)

550. Airlock Hatch Panel Section X_o 576.0 Bulkhead. (000550)

551. Payload Bay Door Seal Upper Section of X_o 576.0. 29" × 3 1/2". (000551)

552. Payload Bay Door Seal Upper Section of X_o 576.0 25" × 3 1/2". (000552)

553. Payload Bay Door Seal Upper Section of X_o 576.0 8" × 3". (000553)

554. Payload Bay Door Lock Roller with Structure, X_o 576.0 Bulkhead. V070-310344-002. (000554)

555. Payload Bay Door Lock Roller with Structure, X_o 576.0 Bulkhead. (000555)

556. Payload Bay Door Lock Roller with Structure, X_o 576.0 Bulkhead. (000556)

557. Payload Bay Door Lock Roller with Structure, X_o 576.0 Bulkhead. (000557)

558. DC Power Cables with Structure. X_o 576.0 Bulkhead. (000558)

559. Stowage Frame, Extra Vehicular Activity Suit, Partial. (000559)

560. Audio Terminal Unit/ with Pressure Vessel Structure. (000560)

561. Water Tank, Partial, (Ref. V070-623021-004, C41218). (000561)

562. Structure, Pressure Vessel with 3" diameter Feed Thru. (000562)

563. Structure, Pressure Vessel with "I" Beam. (000563)

564. Structure, Pressure Vessel Section, Possible Window Area. (000564)

565. Water Tank, Partial, with Sensor. (000565)

566. Panel, Flight Deck. Partial, with Structure. (000566)

567. Stiffener, Mid Deck Sidewall, R/H Side. (000567)

568. Aluminum Brace, Possible Flight Deck Console. V070-335178-002, B26125. (000568)

569. "C" Channel, Aluminum. With Internal Measurement Unit Mount, Partial. (000569)

570. Intercoastal. Aluminum. No P/N. (000570)

571. Stiffener. Aluminum. No P/N. Environmental Control Life Support System Bay. (000571)

572. Structure, heavy aluminum. Possible Inertial Measurement Unit Pallet. Ref. V070-334143-009, B79844 (000572)

573. Stiffener, Aluminum. No P/N. (000573)

574. Access Door, Partial. No P/N. (000574)

575. Structure, Pressure Vessel. Possible window area. (000575)

576. LIOH Container. Divider. (000576)

577. Sidewall Closeout with Air Duct. Mid Deck. (000577)

578. Volume, Partial. No I.D. (000578)

579. LIOH Container Lid, Partial. (000579)

580. Pressure Vessel Structure with Feed Thru. Ref. V070-337573-003, B78232-2. (000580)

581. Pressure Vessel Structure. No P/N. (000581)

582. Panel, Aluminum. Milled. V070-703912-001, C47532. (000582)

583. Panel, Flight Deck. Vented, V627-335186-002. (000583)

584. Duct, Aluminum. No I.D. (000584)

585. Stiffener, Mid Deck Sidewall with Closeout. (000585)

586. Pressure Vessel Structure with Feed Thru. Ref. V070-332825-005, C28964. (000586)

587. Side Hatch Cover, Inner, Partial. (000587)

588. Channel, Aluminum. Ref. C38554. (000588)

589. Closeout, Waste Collection System Compartment. (000589)

590. Heat Exchanger with Structure. Possible. V070-623202-011 AH9511. (000590)

591. Feed Thru Plate, Water. (000591)

592. Rudder Pedal Assembly, Partial. V070-573003-006. (000592)

593. Input/Output Processor #5, MC615-0001-0312. (000593)

594. Rudder Pedal Assembly, Partial. V070-573004-003, (000594)

595. Air Data Transducer, MC409-0011-0006, S/N W0018003. (000595)

596. Line Replaceable Unit, Partial. No I.D. (000596)

597. Line Replaceable Unit, MC615-0004-5110, S/N 009060058 (000597)

598. Heads Up Display Electrical Unit. MC409-0096-0012, S/N 116. (000598)

599. Line Replaceable Unit with Structure, Partial. No I.D. (000599)

600. Line Replaceable Unit, Partial, No I.D. (000600)

601. Multiplexer/Demultiplexer 81V72A32 with shelf. LF1. (000601)

602. Line Replaceable Unit. No I.D. (000602)

603. Line Replaceable Unit. No I.D. Possible Internal Measurement Unit. (000603)

604. Line Replaceable Unit, No I.D. Possible Internal Measurement Unit. (000604)

605. Access Door/Volume "A". (000605)

606. Hatch Frame "A", Lower Section. (000606)

607. Structure, Aluminum. Flight Deck Floor—Possible. (000607)

608. Overhead Communication Panel, Mid Deck. Partial. (000608)

609. Star Tracker Structure with Drive Unit—Possible. (000609)

610. Mid Deck Floor—under Airlock. (000610)

611. Structure with Access Door. No I.D. (000611)

612. Hatch Assembly "A". (000612)

613. Structure, Pressure Vessel. No I.D. (000613)

614. Beam, Aluminum. Partial, No I.D. (000614)

615. Door, MD23R, V070-336762-001, AD5095. (000615)

616. Water Tank, Partial. No I.D. (000616)

617. Pressure Vessel Structure, Environmental Control Life Support System Area. (000617)

618. Pressure Vessel Structure. No I.D. (000618)

619. Flight Deck Floor Section. (000619)

620. Flapper Valve, SV719772-1, L/N 2. (000620)

621. Pressure Vessel. No I.D. (000621)

622. Rotational Hand Controller—Forward. (000622)

623. Door. MD76C Access Door. (000623)

624. Filter Canister Structure. V070-X3680X. (000624)

625. Pressure Vessel. No I.D. (000625)

626. Access Panel, Partial. V070-333250-003, N15599. (000626)

627. Beam, Partial. 576.0 Bulkhead. (000627)

628. Intercostal, Partial Possible 576.0 Bulkhead. (000628)

629. Intercostal, Partial with tube assemblies. (000629)

630. Structure, Aluminum. Milled. No I.D. (000630)

631. Electrical Feed Thru—V070-793255-002, SN C28957. (000631)

632. Electrical Feed Thru—No P/N. (000632)

633. Access Door. Mid Deck Floor. V070-334027-001, S/N 006333. (000633)

634. Tube, Aluminum. 48" × 2" diameter. No I.D. (000634)

635. Line Replaceable Unit. Partial. Top or Bottom Plate. No I.D. (000635)

636. Intercostal, 72" × 5" with coolant lines. (000636)

637. Outer Structure, L/H at Mid Deck Floor Level. (000637)

638. Intercostal, 66" × 4 1/2". No I.D. (000638)

639. Intercostal, 55" × 4 1/2". No I.D (000639)

640. Structure, Aluminum. Access Hole, Bolt Flange and O-ring. (000640)

641. Frame Section, Aluminum. Ref. V070-321083-013, SN J41019. (000641)

642. Rudder Pedal Transducer Assembly, with Structure. MC621-0043-3440, S/N 0007. (000642)

643. Line Replaceable Unit and Avionics Bay, Partial. Ref. V070-703116-00, S/N C41821. (000643)

644. Aluminum Structure. Primary. No I.D. (000644)

645. Electrical Feed Thru, Partial. C/M mid deck. V070-338502-003, B78429. (000645)

646. Water Tube Assembly with Structure, 35 psi. Ref. V070-336537-002, 879606. (000646)

647. Adapter Plate, Mid Deck Floor. V070-334271-006, S/N BE5528. (000647)

648. Air Duct & Bracket. V070-336446-004, SN B79598. (000648)

649. Pressure Vessel Structure. No I.D. (000649)

650. Structure, Aluminum. C/M Interior. (000650)

651. Pressure Vessel Structure. No I.D. (000651)

652. Outer Pressure Vessel Structure. No I.D (000652)

653. Access Door, Partial, Fiberglass and Honeycomb. (000653)

654. Airlock Structure, Honeycomb, Floor or Ceiling. (000654)

655. Channel, Aluminum, with Tube Assemblies. Ref. V070-613340-002, B16938. (000655)

656. Air Duct & Flex Coupling with Bracket. Ref. V581-613896-001, S/N AE4871. (000656)

657. Structure, Aluminum. 38" × 17". No I.D. (000657)

658. Avionics Bay Shelf #3, Bay 3B. Partial. (000658)

659. Structure, Aluminum. Milled. No I.D. (000659)

660. Structure, Aluminum. Ref. MR TT7743-000M. (000660)

661. Airlock Structure, Honeycomb, Floor or Ceiling. (000661)

662. Pressure Vessel Structure, Environmental Control Life Support System Bay. (000662)

663. Water Separator Units with structure. 2 Ea. (000663)

664. Heat Exchanger. No I.D. (000664)

665. Structure. Aluminum. No I.D. (000665)

666. Filter Screen Assembly. No I.D. (000666)

667. Structure, Aluminum. 10" × 2". No I.D. (000667)

668. Pressure Vessel Structure. No I.D. (000668)

669. Structure, Aluminum. 64" × 2". No I.D. (000669)

670. Retainer, Mid Deck Sidewall/Ceiling. (000670)

671. Channel, Aluminum. Mid Deck Avionics Bay. (000671)

672. Structure, Aluminum. Milled. No I.D. (000672)

673. Star Tracker Boom/Mount. V070-331432-001, S/N 7065688 (000673)

674. Structure, Aluminum. No I.D. 36" × 4". (000674)

675. Pressure Vessel, 576.0 Bulkhead. (000675)

676. Line Replaceable Unit. Partial. No I.D. (000676)

677. C-2, Partial, with structure. (000677)

678. Heads Up Display Mount, Partial Ref. V070-732409-001 SN BP1837. (000678)

679. HandHold Forward Window Area. (000679)

680. Channel, Aluminum. V070-336909-001. (000680)

681. Structure, Aluminum, with Access Plate. V070-6743208-003, S/N F85695. (000681)

682. Structure, Pressure Vessel. No I.D. (000682)

683. Structure, Aluminum. 58" × 2". (000683)

684. Line Replaceable Unit, Partial. No I.D. (000684)

685. Air Vent, Flight Deck Forward Panel Area. (000685)

686. Panel, Partial, with Velcro. No I.D. (000686)

687. F-8 Pressure & Temperature Meter. Auxiliary Power Unit. MC432-0232-0008, S/N 001. (000687)

688. Structure, Fiberglass, with wiring. 20V77W2J74. (000688)

689. Side Hatch Collar Structure, 30½" long. (000689)

690. Structure, Aluminum. 17" × 7". No I.D. (000690)

691. Structure, Primary 16" × 14". No I.D. (000691)

692. Stiffener, Pressure Vessel, 40" × 3½". (000692)

693. Structure, Aluminum. 16" × 4½", Ref. 30TB25. (000693)

694. Structure, Aluminum. 19" long, V070-333702-007, S/N B78218. (000694)

695. Line Replaceable Unit Mount with Air Duct Interface V070-703756-001, S/N C47524. (000695)

696. Structure. Pressure Vessel. No I.D. 25" × 14". (000696)

697. M0525 Panel, Utility Power. (000697)

698. Line Replaceable Unit, Partial. No I.D. (000698)

699. Flight Deck Container with Structure. Ref. V070-333277-002, AM 7255. (000699)

700. Honeycomb, Aluminum. No I.D. (000700)

701. Structure Pressure Vessel, with Feed Thru. (000701)

702. Structure, Pressure Vessel, Bulkhead Feed. (000702)

703. Fire Extinguisher Container, Halon, MC282-0065-0001 S/N 02134. (000703)

704. Panel, Flight Deck, 33V73A17. (000704)

705. Switch Panel, No I.D. (000705)

706. Flight Deck Container. Partial. (000706)

707. Switch Panel, No I.D. (000707)

708. Switch Panel, No I.D. (000708)

709. Switch Panel, 36V73A13. (000709)

710. Shock Mount Assembly with Partial Line Replaceable Unit. MC409-0017-0005, S/N 0019. (000710)

711. Line Replaceable Unit Case, Partial. 34024266-001. (000711)

712. Mounting Plate Aluminum. No I.D. (000712)

713. Structure, Aluminum. Interior, 25" long. (000713)

714. Structure, Aluminum. 28" × 4 1/2", 576 Bulkhead. (000714)

715. Structure, Aluminum. 11" × 4", 576 Bulkhead. (000715)

716. Structure, Aluminum. Interior, V070-337682-001, S/N 17200. (000716)

717. Structure, Aluminum. V070-339018-001, C49796. (000717)

718. Floor panel Section, No I.D. (000718)

719. Structure, Pressure Vessel Structure. No I.D. (000719)

720. Brace, Aluminum. Milled. No I.D. 20" long. (000720)

721. Channel, Aluminum. V070-338512-001, C35223. (000721)

722. Structure, Aluminum. No I.D. 15" × 6". (000722)

723. Structure, Aluminum. Interior, 17" × 15". (000723)

724. Structure, Aluminum, with Tube Assemblies, V070-612869-019, S/N B84858. (000724)

725. Tube Assemblies with Feed Thru Plate. (000725)

726. Angle, Aluminum. No I.D. 12" long. (000726)

727. Channel, Aluminum. No I.D. 23" long. (000727)

728. Structure. Aluminum. 29" × 4". No I.D. (000728)

729. Air Duct, Partial. No I.D. (000729)

730. Structure, Outer Pressure Vessel. 12" × 12". (000730)

731. Structure, Pressure Vessel, 576 Bulkhead. (000731)

732. Light Assembly. No P/N. (000732)

733. Line Replaceable Unit. Partial. No I.D. (000733)

734. Line Replaceable Unit. Partial. No I.D. (000734)

735. Line Replaceable Unit. Partial. No I.D. (000735)

736. Line Replaceable Unit. Partial. No I.D. (000736)

737. Line Replaceable Unit. Partial. No I.D. (000737)

738. Structure, Aluminum with Purge Boot and Retainer. V070-320585-015, S/N 6523553. (000738)

739. Tube Support, Aluminum. V070-334999-001, S/N B42581. (000739)

740. Water Tank, Partial. No I.D. (000740)

741. Line Replaceable Unit Mount with Air Duct. V070-730730 001, S/N B18630. (000741)

742. Structure, Aluminum. V070-3378X6-001, B679982. (000742)

743. Structure, Pressure Vessel. 18" × 15", No I.D. (000743)

744. Stiffener, Pressure Vessel. No I.D. (000744)

745. Light Assembly. No I.D. (000745)

746. Structure, Aluminum, with RF Shield. No I.D. (000746)

747. Structure, Aluminum, with Feed Thru, 17" × 13". (000747)

748. Structure, Aluminum, Floor Section. No I.D. (000748)

749. Duct Section, Inertial Measurement Unit. A71079. (000749)

750. Light Assembly. No I.D. (000750)

751. Water Tank Section. No I.D. (000751)

752. Structure, Aluminum, Primary. V070-332624-001, S/N 10616-002. (000752)

753. Annunciator Control Assembly, Partial. MC434-0283-000X,S/N 48128. (000753)

754. Structure, Pressure Vessel. No I.D. (000754)

755. Structure. Pressure Vessel. No I.D. (000755)

756. Structure, Pressure Vessel. No I.D. (000756)

757. Switch Panel Closeout Plate, XDD33101222-002. (000757)

758. Control Panel; partial. V075-643021-002. (000758)

759. Structure, Aluminum. No I.D. 25" long. (000759)

760. Structure, Aluminum. Interior, No I.D. 11" × 8". (000760)

761. Window Frame Component, No I.D. (000761)

762. Window Frame Component. No I.D. (000762)

763. Tube Support, Aluminum. No I.D. 15" × 3/4" OD. (000763)

764. Channel, Aluminum. V070-334919-001-B45828. (000764)

765. Line Replaceable Unit, Partial. No I.D. (000765)

766. Closeout Panel, Partial. 11" × 6". (000766)

767. Water Tube Assemblies, Coolant. V070-6712822-001, (000767)

768. Structure, Aluminum. Low Reflective Paint one side. (000768)

769. Structure, Aluminum. Low Reflective Paint, 9" long. (000769)

770. Structure with window Carrier Panel and window frame. (000770)

771. Structure with window Carrier Panel and window frame. (000771)

772. Structure with Window Frame and Purge Boot. (000772)

773. Orbiter Structure with Window Frame and Carrier Panel (000773)

774. Structure with Window Frame & Purge Boot. (000774)

775. Window Frame—C/M Pressure Vessel, Forward. (000775)

776. Structure, Aluminum. Milled Waffle Pattern &. (000776)

777. Structure, Aluminum. Honeycomb, 11" × 12". (000777)

778. Closeout, Aft Window. Partial (000778)

779. Structure, Pressure vessel. No I.D. 14" × 8". (000779)

780. Line Replaceable Unit, Partial. 2X0-26264-1, S/N 0003 (000780)

781. Pilot Display Unit, Partial. MC409-0096-0021, S/N 103 (000781)

782. Line Replaceable Unit Mount & Avionics Bay Shelf, Partial. V070-703763-003, SN 661512. (000782)

783. Line Replaceable Unit Case. Partial. No I.D. (000783)

784. Console, Partial. SED39110201-301, S/N 10060. (000784)

785. Line Replaceable Unit, Partial. 30V71A13. (000785)

786. Structure, Pressure Vessel, Milled Waffle. (000786)

787. Structure, Aluminum. Interior, No I.D. (000787)

788. Structure, Aluminum. Pressure Vessel. No I.D. (000788)

789. Line Replaceable Unit, Partial. Interior Wiring. (000789)

790. Control Panel, Partial. No I.D. (000790)

791. Channel, Aluminum, with shock mount, 17" × 2". V070-336222-002, E48786. (000791)

792. Line Replaceable Unit, Partial. 35181-FP94368-01. (000792)

793. Control Panel, Partial, No I.D. (000793)

794. Support, Aluminum, Serated, V070-332535-001, SN N18375 (000794)

795. Window Purge Boot Section. No I.D. (000795)

796. Structure, Window Area, with Purge Boot, 17" × 7". (000796)

797. Structure, Aluminum, Primary, 32" × 4½". (000797)

798. Structure, Aluminum. Interior, 22" × 3". (000798)

799. Structure, Aluminum, Milled, No I.D. 8½" × 5". (000799)

800. Structure, Aluminum. Pressure Vessel, 19" × 7". Ref. V070-339308-001, S/N B29438. (000800)

801. Pressure Vessel, Forward Bulkhead Feed 81V70A6. (000801)

802. Fiberglass Closeout, Partial, MC35A. (000802)

803. Structure, Pressure Vessel with Gold Blanket. (000803)

804. Structure, Pressure Vessel, No I.D. (000804)

805. Structure, Pressure Vessel. V070-X32070-002. (000805)

806. Structure, Pressure Vessel. No I.D. 23" × 4". (000806)

807. Structure, Aluminum, Window Frame with O-Ring Groove. (000807)

808. Structure, Aluminum. Interior, V070-335022-001, SN C27082. (000808)

809. Structure, Aluminum. Interior, with Closeout. (000809)

810. Structure, Aluminum. Low Reflective paint One Side. (000810).

811. Structure, Pressure Vessel, No I.D. 12" × 3". (000811)

812. Switch Panel, Partial. No I.D. (000812)

813. Structure, Pressure Vessel. No I.D. (000813)

814. Channel, Aluminum. V070-338513-001, B79538. (000814)

815. Structure, Aluminum. Interior, V070-332976-002, S/N A75438. (000815)

816. Structure, Aluminum. Interior, No I.D. (000816)

817. Structure, Aluminum. Pressure Vessel, 576 Bulkhead. (000817)

818. Structure, Pressure Vessel, 12" × 12". (000818)

819. Structure, Pressure Vessel, 18" × 6". (000819)

820. Control Panel. Partial. No I.D. (000820)

821. Structure, Pressure Vessel, No I.D. 7" × 9". (000821)

822. Rail, Extendable, Aluminum. 47J122941B58. (000822)

823. Feed Thru with connector. Partial. (000823)

824. Structure, Aluminum. Low Reflective Paint. (000824)

825. Structure, Aluminum. Interior, Waffle Pattern. Ref. V070-334932-001, S/N C01040. (000825)

826. Structure, Aluminum. 14" long, Ref. V070-334864-001, S/N B19372. (000826)

827. Structure, Aluminum, with insulation. No I.D. (000827)

828. Window Frame with Purge Boot Section. (000828)

829. Tube Assemblies, V070-613869-068, E64427. (000829)

830. Structure, Aluminum, Secondary No I.D. 13½" × 1". (000830)

831. Structure/Angle brace, Aluminum. V070-334107-005, S/N C38554. (000832)

833. Structure, Aluminum. Milled. Large Waffle Pattern. (000833)

834. Structure. Pressure Vessel. No I.D. 12" × 5". (000834)

835. Structure. Pressure Vessel. No I.D. 34" × 3". (000835)

836. Channel, Aluminum. V070-334396-001-F84906. (000836)

837. Structure, Aluminum. No. I.D. 27" × 4". (000837)

838. "I" Channel, Aluminum. No I.D. 8" × 1". (000838)

839. Structure, Aluminum. Interior, No I.D. 18" × 1½". (000839)

840. Wave Guide, Flexible. ME413-0038-0028, S/N R0506. (000840)

841. Wave Guide Section, Avionics Bay #1. (000841)

842. Structure, Aluminum. No I.D. 34" × 1½". (000842)

843. Structure, Pressure Vessel. No I.D. (000843)

844. Intercostal, Section. 10½" × 4½". (000844)

845. Gold Blankets, Miscellaneous. No I.D. (000845)

846. Tube Assembly with Support, V070-311112-002. (000846)

847. Tube Assemblies with Structure, V070-613146-017. (000847)

848. Tube Assemblies. Miscellaneous. 4 Ea. (000848)

849. Fiberglass Panel. No I.D. 13" × 20". (000849)

850. Switch Panel, Partial. No I.D. (000850)

851. Blanket,Thermal Control System. No I.D. 40" × 20". (000851)

852. Structure, Aluminum, Primary. No I.D. 23" × 7". (000852)

853. Structure, Aluminum, Primary, No I.D. 30" × 4". (000853)

854. Structure, Aluminum, Pressure Vessel. Miscellaneous. (000854)

855. Line Replaceable Unit Case, Partial, 6" × 7". (000855)

856. Panel, Aluminum. 5" × 6", No I.D. (000856)

857. Pilot Display Unit – Partial. (000857)

858. Structure, Pressure Vessel Structure. No I.D. (000858)

859. Tube Assemblies, V070-592044-134, B79064. (000859)

860. Tube Assemblies, Miscellaneous. No I.D. (000860)

861. Tube Assemblies, Miscellaneous. No I.D. (000861)

862. Tube Assemblies, Miscellaneous. No I.D. (000862)

863. Tube Assemblies, Miscellaneous. No I.D. (000863)

864. Tube Assemblies, Miscellaneous. No I.D. (000864)

865. Line Replaceable Unit, Partial. No I.D. (000865)

866. Diffuser & Air Duct, V070-613412-002, S/N B78339. (000866)

867. Structure, Miscellaneous. Interior. 5 Pieces. (000867)

868. Structure, Aluminum. No I.D. 19" × 2¼". (000868)

869. Structure, Miscellaneous. Interior, 5 Pieces. (000869)

870. Structure, Miscellaneous. Interior, 6 Pieces. (000870)

871. Sheet Metal, Aluminum. V070-339762-001, S/N C47166. (000871)

872. Structure, Aluminum. Ref. (STR-9-09-1717), 23" long. (000872)

873. Line Replaceable Unit Case. Partial. (000873)

874. Tube Assemblies, V070-612873-058, S/N 038695. (000874)

875. Line Replaceable Unit. Partial, No I.D. (000875)

876. Purge Boot & Retainer, No I.D. (000876)

877. Line Replaceable Unit Case, Partial. No I.D. (000877)

878. Structure, Aluminum. 11982A1-716042- 15" × 2". (000878)

879. Tube Assembly with Bracket. No I.D. (000879)

880. Tube Assembly, V070-613191-008, S/N C38578. (000880)

881. Panel, Mid Deck Overhead Structure, Partial. (000881)

882. Switch Panel, Partial. No I.D. (000882)

883. Structure, Aluminum with Honeycomb. No I.D. (000883)

884. Sheet, Aluminum. No I.D. 13" × 9½". (000884)

885. Tube Assembly, V070-613868-008, B84798. (000885)

886. Structure, Aluminum. Interior. 15" × 16". (000886)

887. Channel, Aluminum. Interior. No I.D. (000887)

888. Structure, Aluminum. No I.D. 18" × 4". (000888)

889. Channel, Aluminum. No I.D. 13" long. (000889)

890. ML18F Panel, with Structure. (000890)

891. Panel, Vented, Flight Deck, Partial No I.D. (000891)

892. Structure, Pressure Vessel, No I.D. (000892)

893. Structure, Pressure Vessel, No I.D. (000893)

894. Structure, Pressure Vessel, No I.D. (000894)

895. Mid Deck Floor Section, 31" × 29". (000895)

896. Structure, Pressure Vessel, No I.D. (000896)

897. Structure, Pressure Vessel, 19" × 13". (000897)

898. Channel, Aluminum. Milled, 24" × 2". (000898)

899. Translation Hand Control, MC621-0043-3140, S/N 0005. (000899)

900. L-5 Panel, Partial, with Structure. (000900)

901. Fiberglass Line Support, V070-320900-003. (000901)

902 Aluminum Structure, No I.D. 21" × 16". (000902)

903. Aluminum Structure, V070-334451-001/F30095. (000903)

904. Aluminum Structure, V070-333431-009. (000904)

905. Aluminum Structure, No P/N. 14" × 3½". (000905)

906. Air Duct, with Smoke Detector. No I.D. (000906)

907. Hinge & partial Door, Avionics Bay 3B. (000907)

908. Aluminum Structure, C/M Interior-Pr. 76" long. (000908)

909. Aluminum Structure, C/M Interior. No I.D. (000909)

910. Heat Exchanger, No I.D. (000910)

911. Water Tank, Environmental Control Life Support System Bay, No I.D. (000911)

912. Aluminum Structure with Honeycomb, 93" × 3½". (000912)

913. Structure, C/M Outer Pressure Vessel. No I.D. (000913)

914. Aluminum Structure with Coax Cables, 38" × 4½". (000914)

915. Panel, R15, Partial. (000915)

916. Fluorescent Light Assembly, MC434-0068-0020, S/N 351. (000916)

917. Aluminum Support, V070-336444-004, S/N B93674. (000917)

916. Line Replaceable Unit, Partial. No I.D. (000918)

919. C/M Outer Pressure Vessel. No I.D. 5 Pieces total. (000919)

920. C/M Outer Pressure Vessel. No I.D. 3 Pieces total. (000920)

921. Structure, C/M Interior, No I.D. 4 Pieces total. (000921)

922. C/M Outer Pressure Vessel Structure, No I.D. 2 Pieces total. (000922)

923. C/M Outer Pressure Vessel Structure, No I.D. 4 Pieces total (000923)

924. C/M Outer Pressure Vessel Structure, No I.D. 5 Pieces total. (000924)

925. C/M Outer Pressure Vessel Structure, No I.D. 6 Pieces total. (000925)

926. C/M Outer Pressure Vessel Structure, No I.D. 6 Pieces total. (000926)

927. Aluminum Structure, Low Reflective Paint, one side. (000927)

928. Structure, C/M Outer Pressure Vessel, No I.D. 8 Pieces total. (000928)

929. Structure, C/M Outer Pressure Vessel, No I.D. 16" long. (000929)

930. Aluminum Support, V070-331442-001, S/N F69327. Partial. (000930)

931. Tube Assemblies, 5/8" diameter, No I.D. 50" long. (000931)

932. Retainer, Closeout, 2 Pieces. No I.D. (000932)

933. Line Replaceable Unit, Partial. No I.D. (000933)

934. Structure, C/M Interior, V070-334663-003, S/N B79575. (000934)

935. Structure, C/M Interior with mounting plate, V070-793878-001. (000935)

936. Structure, Waste Collection System Compartment. No I.D. (000936)

937. Structure, C/M Interior, No I.D. 27 1/2" × 7 1/2". (000937)

938. Panel, 0-16, Partial. 7" × 8". (000938)

939. Aluminum Skin, Debonded from Honeycomb. (000939)

940. Structure, C/M Interior with partial Switch Panel. (000940)

941. Aluminum Channel, Milled. 28" × 2". (000941)

942. 2 Pieces Switch Control Panel, No I.D. (000942)

943. Tube Assembly, 28" long, with support. V070-381299-024, S/N B33397. (000943)

944. Aluminum Structure with RF Shield, V645-731501-001, S/N AM6294. (000944)

945. 2 Pieces Aluminum Structure with Honeycomb. (000945)

946. 2 Pieces Aluminum/Honeycomb. No I.D. (000946)

947. Partial Floor Panel. No I.D. 27" × 16". (000947)

948. Closeout Panel, V627-336605-00X. (000948)

949. Fluorescent Light Assembly, AL161A20. (000949)

950. Structure, C/M Outer Pressure Vessel, 2 Pieces. No I.D. (000950)

951. Structure, C/M Outer Pressure Vessel, No I.D. (000951)

952. Structure, C/M Avionics Bay Locker Interface. (000952)

953. Structure, C/M Outer Pressure Vessel, No I.D. 36" × 10". (000953)

954. Structure, with partial Avionics Bay Shelf, Ref. V070-334145-005, S/N C38555. (000954)

955. Aluminum Sheet, Low Reflective paint & RF Shield. (000955)

956. Floor Panel Section with Seat Stud. (000956)

957. Aluminum Structure, Low Reflective Paint, V070-333747-003 S/N B79129. (000957)

958. Line Replaceable Unit Case, Partial. No I.D. (000958)

959. Line Replaceable Unit Case, Partial. 00752-501102-1. (000959)

960. Line Replaceable Unit Case, Partial. No I.D. (000960)

961. Line Replaceable Unit Case, Partial. 34V73A6A9. (000961)

962. Line Replaceable Unit Case, Partial. ACA MC434-0283-00XX. (000962)

963. Structure, Aluminum Outer Pressure Vessel, No I.D. 17" × 24". (000963)

964. 6 Pieces Structure, C/M Interior, No I.D. (000964)

965. Line Replaceable Unit Case, Partial. No I.D. (000965)

966. Aluminum Channel with Dowel Pin. (000966)

967. Avionics Bay Shelf, Partial. 8" × 2". (000967)

968. Line Replaceable Unit Case, Partial. No I.D. (000968)

969. Aluminum Channel with Shock Mounts. V070-613735. (000969)

970. Aluminum Sheet Closeout. Low Reflective Paint. (000970)

971. Aluminum Support, Milled. V070-703913-001, S/N B80966. (000971)

972. Switch Control panel. Partial, with structure, (000972)

973. Stainless Steel Sheet with Fiberglass & Honeycomb. (000973)

974. Structure, C/M Interior. 2 Pieces. (000974)

975. Structure, C/M Pressure Vessel & Interior, 2 Pieces. V070-334444-001, S/N 29152. (000975)

976. Structure, C/M Outer Pressure Vessel, 3 Pieces, No I.D. (000976)

977. Window Frame Section. No I.D. (000977)

978. Tube Assembly, V070-613868-028, S/N B84808. (000978)

979. Tube Assemblies, Insulated. No I.D. (000979)

980. Aluminum Channel, C/M Interior, No I.D. (000980)

981. Closeout Panel, partial. V070-335002-001, S/N B78945. (000981)

982. Fluorescent Light Assembly, Partial. No I.D. (000982)

983. Structure, C/M Interior with wiring. (000983)

984. Avionics Bay Shelf, Partial. 81V72A40. (000984)

985. Partial Line Replaceable Unit, MC434-0068-0027, S/N 518 (000965)

986. Aluminum Support, No I.D. (000986)

987. Fluorescent Light Assembly, Partial. (000987)

988. Locker, Waste Collection System Compartment. Partial. (000988)

989. Aluminum Structure. No I.D. (000989)

990. Aluminum Structure with Console Dowel Pin. (000990)

991. Locker, Partial. Waste Collection System Compartment. (000991)

992. Foot Restraint, Waste Management System, Partial. (000992)

993. Stowage Rack, Extra Vehicular Activity Suit, Partial. (000993)

994. Keyboard, Mission Station. (000994)

995. Line Replaceable Unit with Structure, 82V79A16. (000995)

996. Circuit Breaker Panel, Partial. 0-16. (000996)

997. Terminal Audio Unit, MC409-0005-0012, S/N 0020. (000997)

998. Circuit Breaker Panel, Partial. ML86B. (000998)

999. Aluminum Structure, C/M Interior, No I.D. (000999)

1000. Air Duct, Miscellaneous 5 Pieces Total. (001000)

1001. Cabin Air Duct, Mid Deck Sidewall. No I.D. (001001)

1002. Flexible Duct, V070-732071-001. (001002)

1003. Panel 0-14, Partial with Structure. 4 Pieces. (001003)

1004. Closeout Panel with Access Door. SED39115258-301. (001004)

1005. Structure, C/M Outer Pressure Vessel, 48" × 36". (001005)

1006. Aluminum Structure, Milled. V070-318503-002. (001006)

1007. Structure, C/M Outer Pressure Vessel, No I.D. (001007)

1008. Aluminum Structure, Primary. No I.D. (001008)

1009. Aluminum Structure, Primary. No I.D. (001009)

1010. Stainless Steel Milled Support with Pressure Vessel Structure V070-310676-002. J22976. (001010)

1011. Cabin Air Duct. No I.D. (001011)

1012. Line Replaceable Unit, Partial. No I.D. (001012)

1013. Power Cable, PCP to CIU, C/M Flight Deck. 290-27450-24, S/N 0003, (001013)

1014. Gold Blankets, Miscellaneous. No P/N. (001014)

1015. Cabin Air Ducts, 4 Sections. (001015)

1016. Line Replaceable Unit with Avionics Bay Structure, 82V74A271 (001016)

1017. Line Replaceable Unit Case, partial with Rear Mount. (001017)

1018. Closeout Panel, Partial. No I.D. (001018)

1019. Volume "A" Locker Section, Lower Forward. (001019)

1020. Water Tank, partial. No I.D. (001020)

1021. Access Door, MD54G. (001021)

1022. Structure, Interior, V070-338555-004, S/N E69585. (001022)

1023. Closeout panel, SED39110208-001. (001023)

1024. Outer Pressure Vessel Structure. 3 Pieces. (001024)

1025. Volume "A" Locker Section—Upper Aft. (001025)

1026. Airlock Honeycomb Section. (001026)

1027. Fluorescent Light Assembly, No P/N. (001027)

1028. Structure, Interior. No P/N. (001028)

1029. Structure, Interior. V070-334107-006, S/N C38554. (001029)

1030. Hinge Section with Honeycomb. (001030)

1031. Switch Panel, Partial, with structure. No I.D. (001031)

1032. Structure, V070-339627-002, F71837. (001032)

1033. Closeout Panel with Sleep Station Restraint. (001033)

1034. Milled Structure, MC621-0066-0003, S/N 024. (001034)

1035. Partial Avionics Bay Shelf, E49797. (001035)

1036. Honeycomb Panel. No I.D. (001036)

1037. Panel R15 Support Enclosure, V070-731615-XXX. (001037)

1038. Door, Waste Collection System Compartment Locker. (001038)

1039. Aluminum Structure, C/M Interior, No I.D. (001039)

1040. Switch Panel, Partial. No I.D. (001040)

1041. Structure, with Connector, 81V77W8P121, (81V62A3J1). (001041)

1042. Outer Pressure Vessel Structure, 2 Pieces. No I.D. (001042)

1043. Aluminum Structure, Low Reflective Coating. (001043)

1044. Outer Pressure Vessel Structure, 7 Pieces. No I.D. (001044)

1045. Line Replaceable Unit Case, Partial. No I.D. (001045)

1046. Hinge Section with Honeycomb. (001046)

1047. Closeout Panel Section, STR-9-01-0059. (001047)

1048. Smoke Detector, No I.D. (001048)

1049. Line Replaceable Unit Case, Bottom, No I.D. (001049)

1050. Structure, Interior, 4" × 30". (001050)

1051. Structure, Primary, Possible Internal Measurement Unit Pallet Area. (001051)

1052. Structure, Interior, 3 Pieces. No I.D. (001052)

1053. Lower Mid-Deck Galley Pieces, 12 each. Tagged -1 thru -12. (001053)

1054. Pressure Cabin Structure, 4 Pieces. Tagged -1 thru -2. (001054)

1055. Avionics Bay Support Structure, 2 Pieces. Tagged -1 thru -2. (001055)

1056. Aft end of Line Replaceable Unit. (001056)
1057. Avionics Bay Channel Structure. (001057)
1058. Structure, Outer Pressure Vessel, 8 Pieces. No I.D. (001058)
1059. Support, aluminum, milled, V581-703001. (001059)
1060. Switch Panel, Partial. R2. (001060)
1061. Adjustment Rod with Structure, F84689. (001061)
1062. Closeout Panel, Airlock Sidewall. (001062)
1063. Panel, Aluminum. (001063)
1064. Panel Section, Floor, with Seat Stud. (001064)
1065. Line Replaceable Unit, Partial. (001065)
1066. Structure, Low Reflective paint, Partial Handhold. (001066)
1067. Sheet, Aluminum, with Low Reflective Paint, V070-339361-008, E46359. (001067)
1068. Sheet, Aluminum, with RF shield. (001068)
1069. Closeout Panel, Vented, No I.D. (001069)
1070. Switch Panel, partial, with structure. V070-335007-002, C17451 (001070)
1071. Channel, Aluminum. Milled, S/N B26124, V070-335178-00 (001071)
1072. Structure, Aluminum, Primary, V070-334104-01X, S/N B79844. (001072)
1073. Drive Unit with Engage/Disengage Lever. (001073)
1074. Structure, with 2 each connections. (001074)
1075. Stowage Area Door, Waste Collection System Compartment. (001075)
1076. Pressure Bulkhead Structure, with Feed Thru. (001076)
1077. Aluminum Angle, No P/N. (001077)
1078. Star Tracker Assembly, MC431-0128-0012, S/N 007. (001078)
1079. Switch Panel, L1/A1. (001079)
1080. Structure, Floor, with Feed Thru. V070-643026-002, S/N A76675. (001080)
1081. Interior Structure, 22 Pieces, Miscellaneous. (001081)
1082. Panel Section,Floor, with partial Line Replaceable Unit. (001082)
1083. Interior Structure, No P/N. (001083)
1084. Window Related Structure, 5 Pieces. No P/N. (001084)
1085. Line Replaceable Unit Case, Partial. (001085)
1086. Panel, "O"-17, Partial, with structure. (001086)
1087. Interior Structure, No P/N. (001087)
1088. Structure, Primary, Low Reflective Paint. (001088)
1089. Structure, Interior, with Connection Feed Thru. (001089)
1090. Structure, Milled Channel, V070-793148-001, S/N E47461. (001090)
1091. Structure, Low Reflective Paint and RF Shield. (001091)
1092. Switch Panel, partial, S/N C36973. (001092)
1093. Line Replaceable Unit, Partial. (001093)
1094. Closeout Panel, Partial. No P/N. (001094)
1095. Air Diffuser with Structure and Partial Panel (001095)
1096. Closeout Panel Retainer, V070-334485-004, S/N B21316. (001096)
1097. Structure, with Laminated Spacer. V070-338523-001, S/N BX8786. (001097)
1098. Structure, Aluminum Tube, 27" × 1½" diameter. (001098)
1099. Switch and Closeout Panel, Partial. (001099)
1100. Structure with RF Shield. V070-335053-003. (001100)
1101. Switch Panel, Partial. No I.D. (001101)
1102. Switch panel, "F" 5, Partial. (001102)
1103. Closeout Panel, Partial. V070-333811-XXX, S/N B30567. (001103)
1104. Panel, Aluminum, No I.D. (001104)
1105. Line Replaceable Unit, Partial, Connector End. (001105)
1106. Switch Panel, Partial, "O"-14. (001106)
1107. Circuit Breaker Panel, Partial, ML86B. (001107)
1108. Switch Panel, Partial, V070-XX1810-XXX, S/N B389XX. (001108)
1109. Structure, Channel, Milled, S0039110206-002. (001109)
1110. Display Panels, Floor Sweepings, 1 Bag. (001110)
1111. Structure, Pressure Vessel, 14" × 18". (001111)
1112. Structure, Pressure Vessel, Sidewall Support. (001112)
1113. Structure, Pressure Vessel with ⅜" Threaded Inserts. (001113)
1114. Duct, Cabin Air, 28" long. (001114)
1115. Line Replaceable Unit with Air Duct, Partial. (001115)
1116. Airlock "A" Hatch Hold Open Fitting. (001116)
1117. Zinc-Air WCCU Battery Assembly, 20 each. (001117)
1118. Battery Array Flex, 6 each. (001118)
1119. LIOH Canister, Environmental Control Life Support System. (001119)
1120. LIOH Canister Holder with LIOH Cans. (001120)
1121. LIOH Canister Holder with 3 each LIOH Cans. (001121)
1122. Battery, SV767789-02, S/N 1122. (001122)
1123. Battery, SV767780-05, S/N 1015. (001123)
1124. LIOH Canister Stowage Locker with 9 Cans. (001124)
1125. Structure, Aluminum Tube, No I.D. (001125)
1126. Stowage Locker, Waste Collection System Compartment. Partial. (001126)
1127. Handhold, Partial. Forward Window Area. (001127)
1128. Structure, Pressure Vessel, 17" × 11". (001128)
1129. Stowage Locker, Waste Control System, Partial. (001129)
1130. Panel, "F-6", Partial, with Structure. (001130)
1131. Panel, Floor, Partial with tape foot restraint. (001131)
1132. RF Assembly, Partial. 500954-2, S/N 018, MC409-0017-0003. (001132)
1133. Panel, "0-1", Partial. 33V73A1. (001133)
1134. Debris Boot & Retainer. 2 Pieces. (001134)
1135. Structure, Pressure Vessel, 12" × 20". (001135)
1136. Structure, Aluminum Milled, Ref. (ECL-9-01-0070). (001136)
1137. Structure, Aluminum panel, Interior. (001137)
1138. Structure, Pressure Vessel, 6" × 15". (001138)
1139. Structure, Miscellaneous Bulkhead Components. 5 Pieces. (001139)
1140. Structure, Aluminum Plate with Feed Thru Connections. (001140)
1141. Retainer, Closeout Panel, Mid-Deck. (001141)
1142. Panel, Closeout, Partial. No I.D. (001142)
1143. Glare Shield Panel, Partial. (001143)
1144. Fire Extinguisher Mount, Ref. B32563. (001144)
1145. Structure, Aluminum Support, V070-336006-001, S/N C02029. (001145)
1146. Panel, "F-6", Partial. 34V73A6A1. (001146)
1147. Structure, Milled Aluminum, Primary. (001147)
1148. Structure, Pressure Vessel, 6" × 40". (001148)
1149. Switch Panel, partial. V070-732155-006, SN E64018. (001149)
1150. Aluminum Sheet, Glare Shield, S/N E71298. (001150)
1151. Light Assembly, Low Reflective Paint. S/N 266. (001151)
1152. Panel, Closeout, Vented, V070-339616-004, S/N B38784. (001152)
1153. Line. Replaceable Unit Mount, Rear with Air Duct V070-703730-001. (001153)
1154. Light Assembly, V070-337701-009, S/N C37452. (001154)
1155. Mounting Plate, Line Replaceable Unit, V070-703873. (001155)
1156. Structure, Milled Waffle Pattern. (001156)
1157. Line Replaceable Unit, Partial. (001157)
1158. Panel, "M069M" Oxygen Panel. (001158)
1159. Closeout Panel, Partial. 2 pieces. (001159)
1160. Rib Section with Intercostal. (001160)
1161. Structure, Interior. (001161)
1162. Structure, Aluminum, V070-333037-004, S/N AN0899. (001162)
1163. Aluminum Sheet, Interior. (001163)

1164. Structure, Aluminum, primary (001164)

1165. Structure, Pressure Vessel, 3 pieces. (001165)

1166. Flange, Round Shape. (001166)

1167. Window Frame, Partial, 2 pieces. (001167)

1168. Aluminum Channel, SDD39110206-001. (001168)

1169. Switch Panel Guard, Partial. (001169)

1170. Line Replaceable Unit, Partial. (001170)

1171. Galley, Partial, with Oven Fan Switch. (001171)

1172. Structure,- Closeout panel, V612-660602-001, S/N F69402. (001172)

1173. Miscellaneous Debris from 576 Bulkhead. (001173)

1174. Structure, Pressure Vessel. (001174)

1175. Closeout Curtain, No P/N. (001175)

1176. Intercoastal, V070-337651-001, C12984. (001176)

1177. Structure, Aluminum with RF Shield, S/N G05016. (001177)

1178. Closeout Panel, Partial. V070-333496-001, S/N F77503. (001178)

1179. Window Frame Structure, 5 Pieces. (001179)

1180. Debris Boot and Retainer, 4 Pieces. (001180)

1181. Switch Panel, Partial. V070-732210-001, S/N E69046. (001181)

1182. Switch Panel, Partial. 34V73A8A4. (001182)

1183. Switch Panel, Partial. 33V73A19. (001183)

1184. Switch Panel, Partial. 33V73A9. (001184)

1185. Aluminum Support, Primary Structure. V070-334107-005, S/N C38554. (001185)

1186. Aluminum Fitting, V070-623 0XX-002. (001186)

1187. Latch Assembly, Partial, Side Hatch. (001187)

1188. Miscellaneous Glass, Window Fragments. (001188)

1189. Aluminum Hat Sections, 2 Ea. V070-334862-XXX, S/N C00132. (001189)

1190. Structure, Pressure Vessel, 8 Pieces. (001190)

1191. Structure, Primary, S/N C68738. (001191)

1192. Structure, Bulkhead Rib Partial. 4 Pieces (001192)

1193. Aluminum Channel, milled, Ref. 85E1. (001193)

1194. Console Frame, Partial. No I.D. (001194)

1195. Closeout Panel Retainer, 2 Pieces. (001195)

1196. Switch Panel, Partial, V070-730396-001. (001196)

1197. Aluminum Structure, with Privacy Curtain Bracket. (001197)

1198. Negative Pressure Relief Valve, MC250-0002-0075, S/N 007. (001198)

1199. Structure, Intercoastal, V070-332592-026. (001199)

1200. Structure, Intercoastal, Ref. 30TB14. (001200)

1201. Structure, Aluminum Rib, Partial. (001201)

1202. Aluminum Channel, Milled, Console Support Structure. (001202)

1203. Airlock Bottom, 5' × 3'7". (001203)

1204. Miscellaneous Honeycomb & Face Sheet Pieces. (001204)

1205. Miscellaneous Structure, Forward Window/Glare Shield. (001205)

1206. Miscellaneous Printed Circuit Boards. (001206)

1207. Miscellaneous Line Replaceable Unit Components. (001207)

1208. Miscellaneous Non-Structure Items with Part Numbers. (001208)

1209. Miscellaneous Switch Panel Components. (001209)

1210. Wire Harness Clamps & Grommets. (001210)

1211. Miscellaneous Electrical Components. (001211)

1212. Miscellaneous Electrical Connectors. (001212)

1213. Miscellaneous Non-Metal Components. (001213)

1214. Miscellaneous Non-Metal Components. (001214)

1215. Miscellaneous Structure Pieces, Pressure Vessel. (001215)

1216. Miscellaneous Structure Items with Part Numbers. (001216)

1217. Miscellaneous Metal/Non-Structure Items. No Part Numbers. (001217)

1218. Miscellaneous Structure Items, No Part Numbers. (001218)

1219. Miscellaneous Tubing. (001219)

1220. Miscellaneous Debris, after sifting. (001220)

1221. Miscellaneous Debris, after sifting. (001221)

APPENDIX B
List of Search Photographs

As part of the Search, Recovery and Reconstruction Team effort, a library of Underwater Search Photographs was maintained. Once a photograph was taken, copies were provided to JSC, MSFC, and the Supervisor of Salvage, USN. The master photograph was kept in the data viewing area, Room 2174, Headquarters Building, KSC.

Photos were given an SRR Team number and local experts provided a characterization of the photo and attempted to identify the source of the debris, i.e. SRB, Orbiter, TDRSS, ET and IUS.

This data plus the KSC photo number were entered into a personal computer data base system. This Appendix B is a list of all Underwater Search Photographs logged into the data base as of close of business, May 5, 1986.

Search Photographs were taken during the debris search and characterization phase. Often these video tapes and photographs were taken by vessels with little or no recovery capability. Views are of pieces of debris, although ocean conditions often produced poor or unusable images.

No. 1
R04/14/86

SORTED BY SRR NUMBER
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SRR NUMBER TARGET	PHOTO . #		TAPE NUMBER	SYSTEM	COMMENTS	OOC # NUMBER
0	108 - KSC - 386C - 0 /	0				0
1	108 - KSC - 386C - 735 /	2 -41	012	SRB	PART OF AFT SKIRT RING SEGMENT, TVC CROSSOVER TUBE SLIDE BRACKET IS VISIBLE AS WELL AS TITANIUM CROSSOVER TUBE	0
2	108 - KSC - 386C - 735 /	2 -42			JSL II	0
3	108 - KSC - 386C - 736 /	1 -41		SRB	JSL II, DIVE 1244, (TAPES 012-016)	0
4	108 - KSC - 386C - 735 /	2 -7		SRB	JSL II, SRB AFT SKIRT AFT BSM FORWARD END-SINGLE MOTOR MODULE	0
5	108 - KSC - 386C - 735 /	2 -5		SRB	JSL II, SRB AFT SKIRT STRUCTURE HOLD DOWN POST IN BSM AREA NEAR SINGLE MOTOR NOZZLE	0
6	108 - KSC - 386C - 735 /	2 -6	014	SRB	JSL II, SRB AFT SKIRT - AFT BSM NOZZLE AND LOWER FRAME - SINGLE MOTOR	0
7	108 - KSC - 386C - 736 /	1 -29	012	SRB	JSL II, DIVE 1244, SRB TVC PARTS - FSM ON RT SIDE OF PHOTO	0
8	108 - KSC - 386C - 735 /	2 -3		SRB	JSL II, SRB AFT SKIRT TVC UPPER FRAME ASSY WITH APU SHOCK MOUNT	0
9	108 - KSC - 386C - 735 /	2 -43	012	SRB	JSL II, YELLOW FIBER GLASS FROM NOZZLE	0
10	108 - KSC - 386C - 735 /	2 -2		SRB	JSL II, PHENOLIC BANDS	0
11	108 - KSC - 386C - 735 /	2 -1	013	SRB	JSL II, METAL FRAGMENT	0
12	108 - KSC - 386C - 735 /	2 -44	012	SRB	JSL II, POSSIBLE NOZZLE	0
13	108 - KSC - 386C - 735 /	2 -40		SRB	SRB AFT SKIRT (FSM) FUEL SERVICE MODULE AND SECTION OF LOWER FRAME ASSEMBLY FROM THRUST VECTOR CONTROL SYSTEM	0
14	108 - KSC - 386C - 735 /	2 -39			JSL II, SRB AFT SKIRT TVC PARTS UPPER FRAME HDWE	0
15	108 - KSC - 386C - 735 /	2 -38			JSL II, NO IDENTIFIED FLIGHT HARDWARE	0
16	108 - KSC - 386C - 736 /	1 -43	013	SRB	JSL DIVE 1244, INDETERMINATE (OUT OF FOCUS)	0
17	108 - KSC - 386C - 735 /	37		SRB	JSL II, PIECE OF SRB CLEVIS	0
18	108 - KSC - 386C - 736 /	1 -23		SRB	JSL II, DIVE 1244, (TAPES 012-016), SRB AFT SKIRT TVC PARTS UPPER FRAME AND HYDRAULIC RESERVOIR	0
19	108 - KSC - 386C - 735 /	2 -4			JSL II, YELLOW FIBER GLASS	0
20	108 - KSC - 386C - 736 /	1 -40		SRB	JSL II, DIVE 1244, (TAPES 012-016), POSSIBLE AFT SKIRT	0
21	108 - KSC - 386C - 736 /	1 -39		SRB	JSL II, DIVE 1244, (TAPES 012-016), POSSIBLE AFT SKIRT	0
22	108 - KSC - 386C - 736 /	1 -38		SRB	JSL II, DIVE 1244, (TAPES 012-016), STIFFENER	0
23	108 - KSC - 386C - 736 /	1 -37		SRB	JSL II, DIVE 1244, (TAPES 012-016), NO IDENTIFIABLE HARDWARE	0
24	108 - KSC - 386C - 736 /	1 -36		SRB	JSL II, DIVE 1244, (TAPES 012-016), AFT SKIRT COMPONENT	0
25	108 - KSC - 386C - 736 /	1 -34	013	SRB	JSL II, DIVE 1244 AFT SKIRT SKIN STRUCTURE	0
26	108 - KSC - 386C - 736 /	1 -35	013	SRB	JSL II, DIVE 1244, AFT SKIRT SKIN STRUCTURE	0

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SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
27	108 - KSC - 386C - 736 / 1 -24	013	SRB	JSL II. DIVE 1244. SRB AFT SKIRT TVC PARTS. HYDRAULIC RESERVOIR	0
28	108 - KSC - 386C - 736 / 1 -25	012	SRB	JSL II. DIVE 1244. SRB AFT SKIRT TVC PARTS. HYDRAULIC RESERVOIR AND UPPER FRAME AND HYDRAULIC TUBING AND HOSES	0
29	108 - KSC - 386C - 736 / 1 -27	012	SRB	JSL II. DIVE 1244. SRB AFT SKIRT TVC PARTS FUEL SUPPLY MODULE	0
30	108 - KSC - 386C - 736 / 1 -28	012	SRB	JSL II. DIVE 1244. SRB AFT SKIRT TVC PARTS. (FSM) FUEL SERVICE MODULE AND SECTIONS OF LOWER FRAME AND UPPER FRAME FOR THE THRUST VECTOR CONTROL SYSTEM (TVC)	0
31	108 - KSC - 386C - 736 / 1 -26		SRB	JSL II. DIVE 1244. (TAPES 012-016). NO IDENTIFIABLE STRUCTURE	0
32	108 - KSC - 386C - 736 / 1 -30		SRB	JSL II. DIVE 1244. (TAPES 012-016). AFT SKIRT STRUCTURE	0
33	108 - KSC - 386C - 736 / 1 -32		SRB	JSL II. DIVE 1244. (TAPES 012-016). NO IDENTIFIABLE STRUCTURE	0
34	108 - KSC - 386C - 736 / 1 -33		SRB	JSL II. DIVE 1244. (TAPES 012-016). TVC TUBE	0
35	108 - KSC - 386C - 736 / 1 -31		SRB	JSL II. DIVE 1244. (TAPES 012-016). AFT SKIRT STRUCTURE	0
36	108 - KSC - 386C - 734 / 1 -42		SRB	JSL II. DIVE 1244. (TAPES 012-016). NOTHING IDENTIFIABLE	0
37	108 - KSC - 386C - 734 / 12			NR-1 (TAPES 053-063)	0
38	108 - KSC - 386C - 734 / 11			NR-1 (TAPES 053-063)	0
39	108 - KSC - 386C - 734 / 10			NR-1 (TAPES 053-063)	0
40	108 - KSC - 386C - 734 / 9			NR-1 (TAPES 053-063)	0
41	108 - KSC - 386C - 734 / 8			NR-1 (TAPES 053-063)	0
42	108 - KSC - 386C - 734 / 7			NR-1 (TAPES 053-063)	0
43	108 - KSC - 386C - 734 / 6			NR-1 (TAPES 053-063)	0
44	108 - KSC - 386C - 734 / 5			NR-1 (TAPES 053-063)	0
45	108 - KSC - 386C - 734 / 4			NR-1 (TAPES 053-063)	0
46	108 - KSC - 386C - 734 / 1			NR-1 TAPES (053-063)	0
47	108 - KSC - 386C - 734 / 3			NR-1 (TAPES 053-063)	0
48	108 - KSC - 386C - 734 / 2			NR-1 (TAPES 053-063)	0
49	108 - KSC - 386C - 734 / 34			NR-1 (TAPES 053-063)	0
50	108 - KSC - 386C - 734 / 33			NR-1 (TAPES 053-063)	0
51	108 - KSC - 386C - 734 / 32			NR-1 (TAPES 053-063)	0
52	108 - KSC - 386C - 734 / 28			NR-1 (TAPES 053-063)	0
53	108 - KSC - 386C - 734 / 27			NR-1 (TAPES 053-063)	0
54	108 - KSC - 386C - 734 / 26			NR-1 (TAPES 053-063)	0
55	108 - KSC - 386C - 734 / 25			NR-1 (TAPES 053-063)	0
56	108 - KSC - 386C - 734 / 24			NR-1 (TAPES 053-063)	0
57	108 - KSC - 386C - 734 / 23			NR-1 (TAPES 053-063)	0
58	108 - KSC - 386C - 734 / 22			NR-1 (TAPES 053-063)	0
59	108 - KSC - 386C - 734 / 21			NR-1 (TAPES 053-063)	0
60	108 - KSC - 386C - 734 / 19			NR-1 (TAPES 053-063)	0

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SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	DOC # TARGET NUMBER
61	108 - KSC - 386C - 734 / 18			NR-1 (TAPES 053-063)	0
62	108 - KSC - 386C - 734 / 16			NR-1 (TAPES 053-063)	0
63	108 - KSC - 386C - 734 / 15			NR-1 (TAPES 053-063)	0
64	108 - KSC - 386C - 734 / 14			NR-1 (TAPES 053-063)	0
65	108 - KSC - 386C - 734 / 13			NR-1 (TAPES 053-063)	0
66	108 - KSC - 386C - 734 / 64			NR-1 (TAPES 053-063)	0
67	108 - KSC - 386C - 734 / 60			NR-1 (TAPES 053-063)	0
68	108 - KSC - 386C - 734 / 59			NR-1 (TAPES 053-063)	0
69	108 - KSC - 386C - 734 / 55			NR-1 (TAPES 053-063)	0
70	108 - KSC - 386C - 734 / 55			NR-1 (TAPES 053-063)	0
71	108 - KSC - 386C - 734 / 52			NR-1 (TAPES 053-063)	0
72	108 - KSC - 386C - 734 / 50			NR-1 (TAPES 053-063)	0
72	108 - KSC - 386C - 734 / 51			NR-1 (TAPES 053-063)	0
73	108 - KSC - 386C - 734 / 49			NR-1 (TAPES 053-063)	0
74	108 - KSC - 386C - 734 / 48			NR-1 (TAPES 053-063)	0
75	108 - KSC - 386C - 734 / 47			NR-1 (TAPES 053-063)	0
76	108 - KSC - 386C - 734 / 46			NR-1 (TAPES 053-063)	0
77	108 - KSC - 386C - 734 / 45			NR-1 (TAPES 053-063)	0
78	108 - KSC - 386C - 734 / 43			NON-SHUTTL3	0
79	108 - KSC - 386C - 734 / 39			NR-1 (TAPES 053-063)	0
80	108 - KSC - 386C - 734 / 38			NR-1 (TAPES 053-063)	0
81	108 - KSC - 386C - 734 / 37			NR-1 (TAPES 053-063)	0
82	108 - KSC - 386C - 734 / 35			NR-1 (TAPES 053-063)	0
83	108 - KSC - 386C - 734 / 101			NR-1 (TAPES 053-063), FACTORY JOINT	0
84	108 - KSC - 386C - 734 / 100		SRB	NR-1 (TAPES 053-063)	11
85	108 - KSC - 386C - 734 / 99		SRB	NR-1 (TAPES 053-063)	11
86	108 - KSC - 386C - 734 / 97		SRB	NR-1 (TAPES 053-063)	11
87	108 - KSC - 386C - 734 / 92		SRB	SHALLOW WATER	11
88	108 - KSC - 386C - 734 / 96		SRB	NR-1 (TAPES 053-063)	11
89	108 - KSC - 386C - 734 / 95		SRB	NR-1 (TAPES 053-063)	11
90	108 - KSC - 386C - 734 / 94		SRB	NR-1 (TAPES 053-063)	11
91	108 - KSC - 386C - 734 / 93		SRB	NR-1 (TAPES 053-063)	11
92	108 - KSC - 386C - 734 / 91		SRB	NR-1 (TAPES 053-063)	11
93	108 - KSC - 386C - 734 / 90		SRB	NR-1 (TAPES 053-063)	11
94	108 - KSC - 386C - 734 / 89		SRB	NR-1	11
95	108 - KSC - 386C - 734 / 88		SRB	SHALLOW WATER	11
96	108 - KSC - 386C - 734 / 87		SRB	NR-1 (TAPES 053-063) - INSIDE VIEW OF CASE, FWD FACTORY JOINT OF AFT SEGMENT - FARTHEST POINT AFT	11
97	108 - KSC - 386C - 734 / 86		SRB	NR-1 (TAPES 053-063)	11
98	108 - KSC - 386C - 734 / 85		SRB	NR-1 (TAPES 053-063)	11
99	108 - KSC - 386C - 734 / 140		SRB	NR-1 (TAPES 053-063)	11
100	108 - KSC - 386C - 734 / 139		SRB	NR-1 (TAPES 053-063)	11
101	108 - KSC - 386C - 734 / 38		SRB	NR-1 (TAPES 053-063)	11
102	108 - KSC - 386C - 734 / 136		SRB	NR-1 (TAPES 053-063)	11
103	108 - KSC - 386C - 734 / 137		SRB	NR-1 (TAPES 053-063)	11
104	108 - KSC - 386C - 734 / 131		SRB	NR-1 (TAPE 053-0630	11
105	108 - KSC - 386C - 734 / 130		SRB	NR-1 (TAPES 053-063)	11

SORTED BY SRR NUMBER

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SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
106	108 - KSC - 386C - 734 / 121		SRB	NR-1 (TAPES 053-063)	11
107	108 - KSC - 386C - 734 / 119		SRB	NR-1 (TAPES 053-063)	11
108	108 - KSC - 386C - 734 / 118		SRB	NR-1 (TAPES 053-063)	11
109	108 - KSC - 386C - 734 / 117		SRB	NR-1 (TAPES 053-063)	11
110	108 - KSC - 386C - 734 / 116		SRB	NR-1 (TAPES 053-063	11
111	108 - KSC - 386C - 734 / 114		SRB	APPEARS TO BE LH UPPER STRUT FITTING - REASONS: SINGLE PLACE CONNECTOR BRACKET IS UNIQUE TO UPPER STRUTS ONLY - DIRECTION "H" FITTING WAS POINTING BEFORE IT WAS SHEARED OFF	11
112	108 - KSC - 386C - 734 / 113		SRB	NR-1	11
113	108 - KSC - 386C - 734 / 112		SRB	NR-1 (TAPES 053-063)	11
114	108 - KSC - 386C - 734 / 111		SRB	NR-1	11
115	108 - KSC - 386C - 734 / 9		SRB	NR-1	11
116	108 - KSC - 386C - 734 / 4		SRB	NR-1	11
117	108 - KSC - 386C - 734 / 3		SRB	NR-1, UPPER STRUT CONNECTOR BRACKET, SINGLE CONNECTOR - LOWER & DIAGONAL ARE TWO PLACE CONNECTOR BRACKETS	11
118	108 - KSC - 386C - 734 / 2		SRB	NR-1	11
119	108 - KSC - 386C - 734 / 128		SRB	NR-1	11
120	108 - KSC - 386C - 734 / 125		SRB	NR-1	11
121	108 - KSC - 386C - 734 / 123		SRB	NR-1	11
122	108 - KSC - 386C - 734 / 122		SRB	NR-1	11
123	108 - KSC - 386C - 734 / 110		SRB	NR-1	11
124	108 - KSC - 386C - 734 / 8		SRB	NR-1	11
126	108 - KSC - 386C - 734 / 98		SRB	NR-1	11
127	108 - KSC - 386C - 734 / 124		SRB	NR-1	11
128	108 - KSC - 386C - 729 / 4 A			NO IDENTIFIABLE HARDWARE	0
129	108 - KSC - 386C - 729 / 5 A			JSL II, DIVES 1248 AND 1249 (TAPES 031-033), NOZZLE RING (?)	0
130	108 - KSC - 386C - 729 / 6 A			JSL II, DIVES 1248 AND 1249 (TAPES 031-033), NOZZLE RING (?)	0
131	108 - KSC - 386C - 729 / 9 A			JS II DIVES 1248 AND 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE	0
132	108 - KSC - 386C - 729 / 10 A	032		JSL II DIVES 1248 AND 1249 PIN RETAINER BAND	0
133	108 - KSC - 386C - 729 / 13 A	032		JSL II DIVES 1248 AND 1249 CARBON & GLASS PHENOLIC	0
134	108 - KSC - 386C - 729 / 12 A	032		JSL II DIVES 1248 AND 1249 (TAPES 031-033)	0
135	108 - KSC - 386C - 729 / 13 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE	0
136	108 - KSC - 386C - 729 / 14 A	032		JSL II DIVES 1248 AND 1249	0
137	108 - KSC - 386C - 729 / 15 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), CARBON & GLASS PHENOLIC	0
138	108 - KSC - 386C - 729 / 16 A	032		JSL II DIVES 1248 AND 1249 CARBON & GLASS PHENOLIC	0
139	108 - KSC - 386C - 729 / 17 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), CARBON & GLASS PHENOLIC	0

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
140	108 - KSC - 386C - 729 /	18 A	032		JSL II DIVES 1248 AND 1249 CARBON & GLASS PHENOLIC	0
141	108 - KSC - 386C - 729 /	19 A	032		JSL II DIVES 1248 AND 1249 CARBON & GLASS PHENOLIC	0
142	108 - KSC - 386C - 729 /	20 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), CARBON & GLASS PHENOLIC	0
143	108 - KSC - 386C - 729 /	21 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO SHUTTLE HARDWARE	0
144	108 - KSC - 386C - 729 /	22 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO SHUTTLE HARDWARE	0
145	108 - KSC - 386C - 729 /	23 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033)CARBON AND GLASS PHENOLIC	0
146	108 - KSC - 386C - 729 /	24 A			JSL II DIVES 1248 AND 1249, CARBON AND GLASS PHENOLIC	0
147	108 - KSC - 386C - 729 /	25 A	032		JSL II DIVES 1248 & 1249	0
148	108 - KSC - 386C - 729 /	26 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033)	0
149	108 - KSC - 386C - 729 /	27 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE	0
150	108 - KSC - 386C - 729 /	28 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), PHENOLIC	0
151	108 - KSC - 386C - 729 /	29 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), PHENOLIC	0
152	108 - KSC - 386C - 729 /	30 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), PHENOLIC	0
153	108 - KSC - 386C - 729 /	31 A	031		JSL II DIVES 1248 AND 1249 PHENOLIC	0
154	108 - KSC - 386C - 729 /	32 A	031		JSL II DIVES 1248 AND 1249 PHENOLIC	0
155	108 - KSC - 386C - 729 /	33 A	031		JSL II DIVES 1248 AND 1249 PHENOLIC	0
156	108 - KSC - 386C - 729 /	34 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE, TARGET 21-1	21
157	108 - KSC - 386C - 729 /	35 A			JSL II DIVES 1248 AND 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE	0
158	108 - KSC - 386C - 729 /	42 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
159	108 - KSC - 386C - 729 /	36 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
160	108 - KSC - 386C - 729 /	37 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
161	108 - KSC - 386C - 729 /	38 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21

SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
162	108 - KSC - 386C - 729 /	39 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
163	108 - KSC - 386C - 729 /	40 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
164	108 - KSC - 386C - 729 /	41 A		SRB	JSL II DIVES 1248 & 1249 (TAPES 031-033), CONTACT 21-3, SRB AFT SEG/STIFFENER/STIFFENER WITH TUNNEL SEGMENT	21
165	108 - KSC - 386C - 728 /	44			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
166	108 - KSC - 386C - 728 /	43			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
167	108 - KSC - 386C - 728 /	42			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
168	108 - KSC - 386C - 728 /	41			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
169	108 - KSC - 386C - 728 /	40			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
170	108 - KSC - 386C - 728 /	39			JSL II DIVES 1248 & 1249, NO IDENTIFIABLE HARDWARE	0
171	108 - KSC - 386C - 728 /	38			JSL II DIVES 1248 AND 1249, CARBON STRIPS	0
172	108 - KSC - 386C - 728 /	37			JSL II DIVES 1248, CARBON STRIPS	0
173	108 - KSC - 386C - 728 /	36			JSL II DIVES 1248 AND 1249, CARBON STRIPS	0
174	108 - KSC - 386C - 728 /	35			JSL II DIVES 1248 AND 1249, CARBON STRIPS	0
175	108 - KSC - 386C - 728 /	32			JSL II DIVES 1248 AND 1249, AFT SKIRT	0
176	108 - KSC - 386C - 728 /	31			JSL II DIVES 1248 AND 1249, AFT SKIRT	0
177	108 - KSC - 386C - 728 /	30			JSL II DIVES 1248 AND 1249, PHENOLIC RING	0
178	108 - KSC - 386C - 728 /	29			JSL II DIVES 1248 AND 1249, PHENOLIC RING	0
179	108 - KSC - 386C - 728 /	28			JSL II DIVES 1248 AND 1249, PHENOLIC RING	0
180	108 - KSC - 386C - 728 /	27			JSL II DIVES 1248 AND 1249, AFT SKIRT STRUCTURE	0
181	108 - KSC - 386C - 728 /	17			JSL II DIVES 1248 AND 1249	0
182	108 - KSC - 386C - 728 /	16			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
183	108 - KSC - 386C - 728 /	15			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
184	108 - KSC - 386C - 728 /	14			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
185	108 - KSC - 386C - 728 /	13			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
186	108 - KSC - 386C - 728 /	12			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
187	108 - KSC - 386C - 728 /	11			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
188	108 - KSC - 386C - 728 /	10		SRB	JSL II DIVES 1248 AND 1249, AFT SKIRT FRAGMENT	0
189	108 - KSC - 386C - 728 /	9			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
190	108 - KSC - 386C - 728 /	8			JSL II DIVES 1248 AND 1249, FRAGMENT	0
191	108 - KSC - 386C - 728 /	7			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
192	108 - KSC - 386C - 728 /	6			JSL II DIVES 1248 AND 1249, NO IDENTIFIABLE HARDWARE	0
194	108 - KSC - 386C - 728 /	4			JSL II DIVES 1248 & 1249 (TAPES 031-033), NO IDENTIFIABLE HARDWARE	0
195	108 - KSC - 386C - 728 /	5		SRB	JSL II DIVES 1248 AND 1249, FRAGMENT	0
196	108 - KSC - 386C - 728 /	4			JSL II DIVES 1248 AND 1249, BLANK VIEW	0
197	108 - KSC - 386C - 772 /	1		SRB	JSL II DIVE 1250 (TAPES 036-037), TGT 26-2, LH SRB AFT CENTER SEG, FWD CYLINDER	26
198	108 - KSC - 386C - 772 /	2		SRB	JSL II DIVE 1250 (TAPES 036-037), TGT 26-2, LH SRB AFT CENTER SEG, FWD CYLINDER	26
199	108 - KSC - 386C - 772 /	3		SRB	JSL II DIVE 1250 (TAPES 036-037), TGT 26-2, LH SRB AFT CENTER SEG, FWD CYLINDER	26
200	108 - KSC - 386C - 772 /	4		SRB	JSL II DIVE 1250 (TAPES 036-037), TGT 26-2, LH SRB AFT CENTER SEG, FWD CYLINDER	26
201	108 - KSC - 386C - 772 /	5		SRB	JSL II DIVE 1250 (TAPES 036-037), TGT 26-2, LH SRB AFT CENTER SEG, FWD CYLINDER	0
202	108 - KSC - 386C - 773 /	7		SRB	JSL II DIVE 1250 (TAPES 036-037)	26
203	108 - KSC - 386C - 773 /	8		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 - LEFT SRB	26
204	108 - KSC - 386C - 773 /	9		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 - LEFT SRB	26
205	108 - KSC - 386C - 774 /	10			JSL II DIVE 1250 (036-037) TGT 26-1	26
206	108 - KSC - 386C - 773 /	11			JSL II DIVE 1250 (TAPES 036-027) TGT 26-1	26
207	108 - KSC - 386C - 773 /	12		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-2 - LEFT SRB, FWD END, AFT CENTER SEGMENT, SERIAL NO. 75	26
208	108 - KSC - 386C - 773 /	13		SRB	JSL DIVE 1250 (TAPES 036-037) TGT 26 - LEFT SRB, FWD END, AFT CENTER SEGMENT, SERIAL NO. 75	26

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
209	108 - KSC - 386C - 772 /	34		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 - LEFT SRB FACTORY JOINT	26
210	108 - KSC - 386C - 772 /	35		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 - LEFT SRB FACTORY JOINT	26
211	108 - KSC - 386C - 772 /	36		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 - LEFT SRB FACTORY JOINT	26
212	108 - KSC - 386C - 772 /	37		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1	26
213	108 - KSC - 386C - 772 /	38		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1 & 182 - AFT END, AFT CENTER SEGMENT, S/N 75, LEFT SRB	26
214	108 - KSC - 386C - 772 /	39		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1	26
215	108 - KSC - 386C - 772 /	40		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-1	26
216	108 - KSC - 386C - 772 /	41		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-2	26
217	108 - KSC - 386C - 772 /	42		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-2 & 182	26
218	108 - KSC - 386C - 772 /	43		SRB	JSL II DIVE 1250 (TAPES 036-037) TGT 26-2 - LEFT SRB, FWD END, AFT CENTER SEGMENT, S/N 75	26
219	108 - KSC - 386C - 772 /	44			NR-1 (TAPES 053-063)	26
220	108 - KSC - 386C - 775 /	35			NR-1	0
222	108 - KSC - 386C - 775 /	33			NR-1 (TAPES 053-063)	0
223	108 - KSC - 386C - 775 /	32			NR-1 (TAPES 053-063)	0
224	108 - KSC - 386C - 775 /	31			NR-1 (TAPES 053-063)	0
225	108 - KSC - 386C - 775 /	4		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
226	108 - KSC - 386C - 776 /	9		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
227	108 - KSC - 386C - 776 /	8		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
228	108 - KSC - 386C - 776 /	7		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
229	108 - KSC - 386C - 776 /	6		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
230	108 - KSC - 386C - 776 /	5		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
231	108 - KSC - 386C - 776 /	4		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
232	108 - KSC - 386C - 776 /	3		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
233	108 - KSC - 386C - 776 /	2		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
234	108 - KSC - 386C - 776 /	1		SRB	NR-1 (TAPES 053-063), FORWARD DOME W/IGNITER	41
235	108 - KSC - 386C - 784 /	37			DEEP DRONE TGT #10 (064-067), NO IDENTIFIABLE HARDWARE	10

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SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
236	108 - KSC - 386C - 784 / 36			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
237	108 - KSC - 386C - 784 / 35			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
238	108 - KSC - 386C - 784 / 34			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
239	108 - KSC - 386C - 784 / 33			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
240	108 - KSC - 386C - 784 / 32			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
241	108 - KSC - 386C - 784 / 31			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
242	108 - KSC - 386C - 784 / 30			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
243	108 - KSC - 386C - 784 / 29			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
244	108 - KSC - 386C - 784 / 28			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
245	108 - KSC - 386C - 784 / 27			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
246	108 - KSC - 386C - 784 / 26			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
247	108 - KSC - 386C - 784 / 25			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
248	108 - KSC - 386C - 784 / 24			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
249	108 - KSC - 386C - 784 / 23			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
250	108 - KSC - 386C - 784 / 22			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
251	108 - KSC - 386C - 784 / 21			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
252	108 - KSC - 386C - 784 / 20			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
253	108 - KSC - 386C - 784 / 19			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
254	108 - KSC - 386C - 784 / 18			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
255	108 - KSC - 386C - 784 / 17			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
256	108 - KSC - 386C - 784 / 16			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
257	108 - KSC - 386C - 784 / 15			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
258	108 - KSC - 386C - 784 / 14			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10
259	108 - KSC - 386C - 784 / 13			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS, NO IDENTIFIABLE HARDWARE	10

SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	DOC # TARGET NUMBER
260	108 - KSC - 386C - 784 / 12			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
261	108 - KSC - 386C - 784 / 11			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
262	108 - KSC - 386C - 784 / 10			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
263	108 - KSC - 386C - 784 / 9			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
264	108 - KSC - 386C - 784 / 6			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
265	108 - KSC - 386C - 784 / 5			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
266	108 - KSC - 386C - 794 / 4			DEEP DRONE TGT #10 (TAPES 064-067). SSME/MPS. NO IDENTIFIABLE HARDWARE	10
267	108 - KSC - 386C - 769 / 44 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
268	108 - KSC - 386C - 769 / 40 A		SRB	DEEP DRONE DIVES 13 & 14	11
269	108 - KSC - 386C - 769 / 39 A		SRB	DEEP DRONE DIVES 13 & 14	11
270	108 - KSC - 386C - 769 / 38 A		SRB	DEEP DRONE DIVES 13&14. UNIDENTIFIABLE	11
271	108 - KSC - 386C - 769 / 37 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
272	108 - KSC - 386C - 769 / 36 A			DEEP DRONE DIVES 13 & 14	11
273	108 - KSC - 386C - 769 / 35 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
274	108 - KSC - 386C - 769 / 34 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
275	108 - KSC - 386C - 769 / 31 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
276	108 - KSC - 386C - 769 / 30 A		SRB		11
277	108 - KSC - 386C - 769 / 29 A		SRB	DEEP DRONE DIVES 13 & 14	11
278	108 - KSC - 386C - 769 / 28 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
279	108 - KSC - 386C - 769 / 27 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
280	108 - KSC - 386C - 769 / 26 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
281	108 - KSC - 386C - 769 / 25 A		SRB	LEFT SRB ET ATTACH	11
282	108 - KSC - 386C - 769 / 24 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
283	108 - KSC - 386C - 769 / 23 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
284	108 - KSC - 386C - 769 / 22 A		SRB	DEEP DRONE. DIVES 13&14. LEFT SRB FACTORY JOINT	11
285	108 - KSC - 386C - 769 / 21 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB FACTORY JOINT	11
286	108 - KSC - 386C - 769 / 20 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
287	108 - KSC - 386C - 769 / 19 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
288	108 - KSC - 386C - 769 / 18 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB FACTORY JOINT	11

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	DOC # TARGET NUMBER
289	108 - KSC - 386C - 769 /	17 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB FACTORY JOINT	11
290	108 - KSC - 386C - 769 /	16 A			DEEP DRONE DIVES 13 & 14	11
291	108 - KSC - 386C - 769 /	15 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
292	108 - KSC - 386 - 769 /	14 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
293	108 - KSC - 386C - 769 /	13 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
294	108 - KSC - 386C - 769 /	12 A		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
295	108 - KSC - 386C - 769 /	11 A		SRB	DEEP DRONE DIVE 13&14. LEFT SRB ET ATTACH	11
296	108 - KSC - 386C - 76 /	10 A		SRB	DEEP DRONE DIVES 13&14. LEFT SRB ET ATTACH	11
297	108 - KSC - 386C - 771 /	31			DEEP DRONE DIVES #13&14. POSSIBLE CABLE	0
298	108 - KSC - 386C - 770 /	44		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
299	108 - KSC - 386C - 770 /	43		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
300	108 - KSC - 386C - 770 /	42		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
301	108 - KSC - 386C - 770 /	41		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
302	108 - KSC - 386C - 770 /	40		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
303	108 - KSC - 386C - 770 /	39		SRB	DEEP DRONE DIVES #13 & 14. SRB SECTION - PROPELLANT GRAIN	0
304	108 - KSC - 386C - 770 /	38		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
305	108 - KSC - 386C - 770 /	37		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
306	108 - KSC - 386C - 770 /	36		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
307	108 - KSC - 386C - 770 /	35		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
308	108 - KSC - 386C - 770 /	34		SRB	DEEP DRONE DIVES 13 & 14. SRB SEDTION	0
309	108 - KSC - 386C - 770 /	33		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
310	108 - KSC - 386C - 770 /	28		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
311	108 - KSC - 386C - 770 /	27		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
312	108 - KSC - 386C - 770 /	26		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
313	108 - KSC - 386C - 770 /	25		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
314	108 - KSC - 386C - 770 /	24		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	0
315	108 - KSC - 386C - 770 /	18		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11
316	108 - KSC - 386C - 770 /	17		SRB	DEEP DRONE DIVES 13 & 14. SRB SECTION	11
317	108 - KSC - 386C - 770 /	16		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11
318	108 - KSC - 386C - 770 /	15		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11
319	108 - KSC - 386C - 770 /	14		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11
320	108 - KSC - 386C - 770 /	13		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11
321	108 - KSC - 386C - 770 /	12		SRB	DEEP DRONE DIVES 13 & 14. LEFT SRB ET ATTACH	11

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
322	108 - KSC - 386C - 770 /	11		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
322	108 - KSC - 386C - 770 /	10		SRB	DEEP DRONE DIVES 13 & 14, SRB SECTION	11
323	108 - KSC - 386C - 770 /	9		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
324	108 - KSC - 386C - 770 /	8		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
325	108 - KSC - 386C - 770 /	7		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
326	108 - KSC - 386C - 770 /	6		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
327	108 - KSC - 386C - 770 /	5		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
328	108 - KSC - 386C - 770 /	4		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
329	108 - KSC - 386C - 770 /	3		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
330	108 - KSC - 386C - 770 /	2		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
331	108 - KSC - 386C - 770 /	1		SRB	DEEP DRONE DIVES 13 & 14, LEFT SRB ET ATTACH	11
332	108 - KSC - 386C - 771 /	1			DEEP DRONE DIVES 13 & 14	0
333	108 - KSC - 386C - 771 /	2			DEEP DRONE DIVES 13 & 14	0
334	108 - KSC - 386C - 771 /	3			DEEP DRONE DIVES 13 & 14	0
335	108 - KSC - 386C - 771 /	4			DEEP DRONE DIVES 13 & 14	0
336	108 - KSC - 386C - 771 /	5			DEEP DRONE DIVES 13 & 14	0
337	108 - KSC - 386C - 771 /	6			DEEP DRONE DIVES 13 & 14	0
338	108 - KSC - 386C - 771 /	7			DEEP DRONE DIVES 13 & 14	0
339	108 - KSC - 386C - 771 /	8			DEEP DRONE DIVES 13 & 14	0
340	108 - KSC - 386C - 771 /	9			DEEP DRONE DIVES 13 & 14	0
341	108 - KSC - 386C - 771 /	10			DEEP DRONE DIVES 13 & 14	0
342	108 - KSC - 386C - 771 /	11			DEEP DRONE DIVES 13 & 14	0
343	108 - KSC - 386C - 771 /	12			DEEP DRONE DIVES 13 & 14	0
344	108 - KSC - 386C - 771 /	13			DEEP DRONE DIVES 13 & 14	0
345	108 - KSC - 386C - 771 /	14			DEEP DRONE DIVES 13 & 14	0
346	108 - KSC - 386C - 771 /	15			DEEP DRONE DIVES 13 & 14	0
347	108 - KSC - 386C - 771 /	16			DEEP DRONE DIVES 13 & 14	0
348	108 - KSC - 386C - 771 /	17			DEEP DRONE DIVES 13 & 14	0
349	108 - KSC - 386C - 771 /	18			DEEP DRONE DIVES 13 & 14	0
350	108 - KSC - 386C - 771 /	19			DEEP DRONE DIVES 13 & 14	0
351	108 - KSC - 386C - 771 /	20			DEEP DRONE DIVES 13 & 14	0
352	108 - KSC - 386C - 771 /	21			DEEP DRONE DIVES 13 & 14	0
353	108 - KSC - 386C - 771 /	22			DEEP DRONE DIVES 13 & 14, SRB SECTION	0
354	108 - KSC - 386C - 771 /	23			DEEP DRONE DIVES 13 & 14, SRB SECTION	0
355	108 - KSC - 386C - 771 /	27			NON-SHUTTLE	0
356	108 - KSC - 386C - 771 /	30			DEEP DRONE DIVES 13 & 14,	0
357	108 - KSC - 386C - 769 /	8 A			NON-SHUTTLE	0
358	108 - KSC - 386C - 769 /	4 A			DEEP DRONE DIVES 13 & 14, NOTHING IDENTIFIABLE	0

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
359	108 - KSC - 386C - 769 /	1 A			NON-SHUTTLE	0
360	108 - KSC - 386C - 768 /	38		SRB	DEEP DRONE DIVES 13 & 14. POSSIBLE SRB PROPELLANT	0
361	108 - KSC - 386C - 768 /	37		SRB	DEEP DRONE DIVES 13 & 14. POSSIBLE SRB PROPELLANT	0
362	108 - KSC - 386C - 768 /	33			NON-SHUTTLE	0
363	108 - KSC - 386C - 768 /	32			NON-SHUTTLE	0
364	108 - KSC - 386C - 768 /	31			NON-SHUTTLE	0
365	108 - KSC - 386C - 768 /	29			NON-SHUTTLE	0
366	108 - KSC - 386C - 768 /	27			NON-SHUTTLE	0
367	108 - KSC - 386C - 710 /	1 A		SRB	JSL II DIVES 1245 & 1246 (TAPES 017-019). RH CASE/TANG SEG	0
368	108 - KSC - 386C - 710 /	2 A		SRB	JSL II DIVES 1245 & 1246 (TAPES 017-019). RH CASE/TANG SEG	0
369	108 - KSC - 386C - 710 /	3 A		SRB	JSL II DIVES 1245 & 1246 (TAPES 017-019)	0
370	108 - KSC - 386C - 710 /	4 A		SRB	JSL II DIVES 1245 & 1246 (TAPES 017-019). SECTION OF SRB AFT SKIRT. SHOWING TRAILING EDGE OF AFT SKIRT AS VIEWED FROM OUTSIDE OF AFT SKIRT	0
371	108 - KSC - 386C - 710 /	5 A		SRB	JSL II DIVES 1245 & 1246 (TAPES 017-019) SECTION OF SRB AFT SKIRT. SHOWING TRAILING EDGE OF AFT SKIRT AS VIEWED FROM OUTSIDE OF AFT SKIRT	0
372	108 - KSC - 386C - 710 /	6 A			JSL II DIVES 1245 & 1246. NO IDENTIFIABLE HARDWARE	0
373	108 - KSC - 386C - 710 /	10 A			JSL II DIVES 1245 & 1246. NO IDENTIFIABLE HARDWARE	0
374	108 - KSC - 386C - 710 /	11 A			JSL II DIVES 1245 & 1246. NO IDENTIFIABLE HARDWARE	0
375	108 - KSC - 386C - 710 /	12 A		SRB	JSLII DIVES 1245&1246. SECTION OF SRB AFT SKIRT. SPLIT OPEN AS VIEWED FROM TOP AND OUTSIDE. CLEVIS LOOKING FEATURE IS THRUST FITTING FOR THRUST VECTOR CONTROL SYSTEM ACTUATOR. 21-1	21
376	108 - KSC - 386C - 710 /	13 A		SRB	JSL II DIVES 1245 & 1246. TGT 21-1	21
377	108 - KSC - 386C - 710 /	14 A		SRB	JSLII DIVES 1245&1246. SECTION OF SRB AFT SKIRT. SPLIT OPEN. AS VIEWED FROM TOP AND OUTSIDE. CLEVIS LOOKING FEATURE IS THRUST FITTING FOR THRUST VECTOR CONTROL SYSTEM ACTUATOR 21-1	21
378	108 - KSC - 386C - 710 /	21 A			JSL II DIVES 1245 & 1246. TGT 21-1	21
379	108 - KSC - 386C - 710 /	22 A			JSL II DIVES 1245 & 1246. NOT IDENTIFIABLE	21
380	108 - KSC - 386C - 710 /	40 A			JSL II DIVES 1245 & 1246. CABLE	21
381	108 - KSC - 386C - 710 /	41 A			JSL II DIVES 1245 & 1246. AFT SKIRT (TGT 21 FIELD)	21
383	108 - KSC - 386C - 710 /	43 A			JSL II DIVES 1245 & 1246	21
384	108 - KSC - 386C - 710 /	7 A			JSL II DIVES 1245 & 1246. NO IDENTIFIABLE HARDWARE	0

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
385	108 - KSC - 386C - 711 /	8 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
386	108 - KSC - 386C - 711 /	9 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
387	108 - KSC - 386C - 711 /	10 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
388	108 - KSC - 386C - 711 /	11 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
389	108 - KSC - 386C - 711 /	12 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
390	108 - KSC - 386C - 711 /	13 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
391	108 - KSC - 386C - 711 /	14 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
392	108 - KSC - 386C - 711 /	15 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
393	108 - KSC - 386C - 711 /	16 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
394	108 - KSC - 386C - 711 /	17 A			JSL II DIVES 1245 & 1246, NO IDENTIFIABLE HARDWARE	0
395	108 - KSC - 386C - 711 /	18 A			JSL II DIVES 1245 & 1246, TGT 21-1	21
396	108 - KSC - 386C - 711 /	19 A			JSL II DIVES 1245 & 1246, TGT 21-1	21
397	108 - KSC - 386C - 711 /	20 A		SRB	JSLII DIVES 1245&1246, SECTION OF AFT SKIRT, KICK RING AREA, PHENOLIC TORN OFF AFT SKIRT CABLE FEED THRU IS RECTANGULAR OPENING WITH PERIPHERAL BOLT PATTERN, AFT SRM SEGMENT, 21-1	21
398	108 - KSC - 386C - 711 /	21 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF SRB AFT SKIRT STRUCTURAL RING, TGT 21-1	21
398	108 - KSC - 386C - 711 /	21 A		SRB	DIFFERENT VIEW, TGT 21-1	21
399	108 - KSC - 386C - 711 /	22 A			JSL II DIVES 1245 & 1246, TGT 21-1	21
400	108 - KSC - 386C - 711 /	23 A		SRB	SECTION OF TRAILING EDGE OF SRB AFT SKIRT VIEWED FROM OUTSIDE, TGT 21-1	21
401	108 - KSC - 386C - 711 /	24 A	0	SRB	JSL II DIVES 1245 & 1246, SRB AFT SKIRT, AFT RING TRAILING EDGE. LOWER THRUST VECTOR CONTROL SYSTEM EXHAUST DUCT. BLUE IS RAIN SHIELD (CURTAIN) ATTACH STRIP. TGT 21-1	21
402	108 - KSC - 386C - 711 /	25 A			JSL II DIVES 1245 & 1246, TGT 21-1	21
403	108 - KSC - 386C - 711 /	26 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF AFT SRM SEGMENT ON TOP OF AFT SKIRT KICK RING SECTION. ORANGE COLOR IS KICK RING PHENOLIC. (3 VIEWS), TGT 21-1	21
404	108 - KSC - 386C - 711 /	27 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF AFT SRM SEGMENT (AFT END) ON TOP OF AFT SKIRT KICK RING SECTION, TGT 21-1	21
405	108 - KSC - 386C - 711 /	28 A			JSL II DIVES 1245 & 1246, TGT 21-1	21
406	108 - KSC - 386C - 711 /	29 A		SRB	JSL II DIVES 1245 & 1246, FRAGMENTS	0

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
407	108 - KSC - 386C - 711 /	30 A		SRB	JSL II DIVES 1245 & 1246, FRAGMENTS	0
408	108 - KSC - 386C - 711 /	31 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF SRB AFT SKIRT SKIN SECTION AND AFT SKIRT/TVC SYSTEM ELECTRICAL CABLING	0
409	108 - KSC - 386C - 711 /	32 A		SRB	SRB THRUST VECTOR CONTROL SYSTEM AUXILIARY POWER UNIT (GREEN) WITH HYDRAULIC PUMP ATTACHED (WHITE) ASSOCIATED ELECTRICAL CABLES AND FLEX HOSE ATTACHED	0
410	108 - KSC - 386C - 711 /	33 A			JSL II DIVES 1245 & 1246	0
411	108 - KSC - 386C - 711 /	34 A			JSL II DIVES 1245 & 1246	0
412	108 - KSC - 386C - 711 /	35 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF AFT SKIRT STRUCTURAL RING AND SKIN, WITH SKIN STIFFENER WEBS PROTRUDING. SOME INSTAFOAM STILL ATTACHED TO RING SECTION	0
413	108 - KSC - 386C - 712 /	23 A		SRB	JSL II DIVES 1245 & 1246, TGT 21-2	21
414	108 - KSC - 386C - 712 /	24 A		SRB	JSL II DIVES 1245 & 1246, PIECE OF SRB AFT SKIRT	0
415	108 - KSC - 386C - 712 /	25 A		SRB	JSL II DIVES 1245 & 1246	0
416	108 - KSC - 386C - 712 /	26 A			JSL II DIVES 1245 & 1246	0
417	108 - KSC - 386C - 712 /	27 A		SRB	JSL II, DIVES #1246, 1246	0
418	108 - KSC - 386C - 712 /	28 A		SRB	JSL II, DIVES #1245 & 1246, PIECE OF AFT SRB SEGMENT	0
420	108 - KSC - 386C - 710 /	0		SRB	JSL II, DIVES #1245 & 1246	0
421	108 - KSC - 386C - 782 /	6			NR-1 (TAPES 053-063)	0
422	108 - KSC - 386C - 782 /	7				0
423	108 - KSC - 386C - 782 /	8			NR-1 (TAPES 053-063)	0
424	108 - KSC - 386C - 782 /	9			NR-1 (TAPES 053-063)	0
425	108 - KSC - 386C - 782 /	10			NR-1 (TAPES 053-063)	0
426	108 - KSC - 386C - 782 /	11			NR-1	0
427	108 - KSC - 386C - 782 /	12			NR-1 (TAPES 053-063)	0
428	108 - KSC - 386C - 782 /	13			NR-1 (TAPES 053-063)	0
429	108 - KSC - 386C - 782 /	14			NR-1	0
430	108 - KSC - 386C - 782 /	15			NR-1 (TAPES 053-063)	0
431	108 - KSC - 386C - 782 /	16			NR-1 (TAPES 053-063)	0
432	108 - KSC - 386C - 782 /	17			NR-1 (TAPES 053-063)	0
433	108 - KSC - 386C - 782 /	18			NR-1 (TAPES 053-063	0
434	108 - KSC - 386C - 782 /	19			NR-1	0
435	108 - KSC - 386C - 782 /	20		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
436	108 - KSC - 386C - 782 /	21		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
437	108 - KSC - 386C - 782 /	22		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
438	108 - KSC - 386C - 783 /	9			NON-SHUTTLE	0
439	108 - KSC - 386C - 783 /	11		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
440	108 - KSC - 386C - 783 /	12		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
441	108 - KSC - 386C - 896 /	16			NON-SHUTTLE	0
442	108 - KSC - 386C - 783 /	18		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
443	108 - KSC - 386C - 783 /	19		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
444	108 - KSC - 386C - 783 /	28		SRB	NR-1 (TAPES 053-063), TGT 21-1	21

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SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
445	108 - KSC - 386C - 795 /	37		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
446	108 - KSC - 386C - 795 /	36		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
447	108 - KSC - 386C - 795 /	31		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
448	108 - KSC - 386C - 795 /	22		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
449	108 - KSC - 386C - 795 /	21		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
450	108 - KSC - 386C - 795 /	20		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
451	108 - KSC - 386C - 795 /	19		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
452	108 - KSC - 386C - 795 /	18		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
453	108 - KSC - 386C - 795 /	16		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
454	108 - KSC - 386C - 795 /	6		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
455	108 - KSC - 386C - 795 /	5		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
456	108 - KSC - 386C - 796 /	36		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
457	108 - KSC - 386C - 796 /	35		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
458	108 - KSC - 386C - 796 /	34		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
459	108 - KSC - 386C - 796 /	33		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
460	108 - KSC - 386C - 796 /	32		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
461	108 - KSC - 386C - 796 /	30		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
462	108 - KSC - 386C - 796 /	29		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
463	108 - KSC - 386C - 796 /	28		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
464	108 - KSC - 386C - 796 /	27		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
465	108 - KSC - 386C - 796 /	24		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
466	108 - KSC - 386C - 796 /	22		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
467	108 - KSC - 386C - 796 /	15		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
468	108 - KSC - 386C - 796 /	11		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
469	108 - KSC - 386C - 796 /	8		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
470	108 - KSC - 386C - 796 /	7		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
471	108 - KSC - 386C - 796 /	5		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
472	108 - KSC - 386C - 796 /	6		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
473	108 - KSC - 386C - 796 /	4		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
474	108 - KSC - 386C - 796 /	3		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
475	108 - KSC - 386C - 796 /	2		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
476	108 - KSC - 386C - 799 /	28		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
477	108 - KSC - 386C - 799 /	31		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
478	108 - KSC - 386C - 799 /	30		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
479	108 - KSC - 386C - 799 /	32		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
480	108 - KSC - 386C - 801 /	1		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
481	108 - KSC - 386C - 801 /	2		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
482	108 - KSC - 386C - 801 /	3		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
483	108 - KSC - 386C - 801 /	4		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
484	108 - KSC - 386C - 801 /	0		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
485	108 - KSC - 386 - 48 /	2		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
486	108 - KSC - 386 - 48 /	3		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
487	108 - KSC - 386 - 48 /	4		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
488	108 - KSC - 386 - 48 /	5		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
489	108 - KSC - 386 - 48 /	6		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
490	108 - KSC - 386 - 48 /	7		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
491	108 - KSC - 386 - 48 /	8		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
492	108 - KSC - 386 - 48 /	9		SRB	NR-1 (TAPES 053-063), TGT 21-1	21

SORTED BY SRR NUMBER

UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
493	108 - KSC - 386 -	48 / 10		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
494	108 - KSC - 386 -	48 / 11		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
495	108 - KSC - 386 -	48 / 12		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
496	108 - KSC - 386 -	48 / 13		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
497	108 - KSC - 386 -	48 / 14		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
498	108 - KSC - 386 -	48 / 15		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
499	108 - KSC - 386 -	48 / 16		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
500	108 - KSC - 386 -	48 / 17		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
501	108 - KSC - 386 -	48 / 18		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
502	108 - KSC - 386 -	48 / 19		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
503	108 - KSC - 386 -	48 / 20		SRB	NR-1 (TAPES 053-063), TGT 21-1	21
504	108 - KSC - 386 -	48 / 21			NR-1	0
505	108 - KSC - 386 -	48 / 22			NR-1	0
506	108 - KSC - 386 -	48 / 23			NR-1	0
507	108 - KSC - 386 -	48 / 24		SRB	NR-1 (TAPES 053-063) PHENOLIC	0
508	108 - KSC - 386 -	48 / 25		SRB	NR-1 PHENOLIC	0
509	108 - KSC - 386 -	48 / 26		SRB	NR-1 PHENOLIC	0
510	108 - KSC - 386 -	48 / 27		SRB	NR-1 FUEL SERVICE MODULE	0
511	108 - KSC - 386 -	48 / 28		SRB	NR-1 FUEL SERVICE MODULE	0
513	108 - KSC - 386 -	48 / 30		SRB	NR-1 FUEL SERVICE MODULE	0
514	108 - KSC - 386 -	48 / 32		SRB	NR-1 PHENOLIC	0
515	108 - KSC - 386 -	48 / 33		SRB	NR-1 PHENOLIC	0
516	108 - KSC - 386 -	48 / 34		SRB	NR-1 PHENOLIC	0
517	108 - KSC - 386 -	48 / 35		SRB	NR-1 PHENOLIC	0
518	108 - KSC - 386 -	48 / 36		SRB	NR-1 PHENOLIC	0
519	108 - KSC - 386 -	48 / 39		SRB	NR-1 PHENOLIC	0
519	108 - KSC - 386 -	48 / 39		SRB	NR-1 PHENOLIC	0
520	108 - KSC - 386 -	48 / 40		SRB	NR-1 PHENOLIC	0
521	108 - KSC - 386 -	48 / 41		SRB	NR-1 PHENOLIC	0
522	108 - KSC - 386 -	48 / 42		SRB	NR-1 PHENOLIC	0
523	108 - KSC - 386 -	48 / 53		SRB	NR-1 PHENOLIC	0
524	108 - KSC - 386 -	48 / 55		SRB	NR-1 PHENOLIC	0
525	108 - KSC - 386 -	48 / 56		SRB	NR-1 PHENOLIC	0
526	108 - KSC - 386 -	48 / 66		SRB	NR-1 PHENOLIC	0
527	108 - KSC - 386 -	48 / 67		SRB	NR-1 PHENOLIC	0
528	108 - KSC - 386 -	48 / 69		SRB	NR-1 PHENOLIC	0
529	108 - KSC - 386 -	48 / 71		SRB	NR-1, POSSIBLE FSM	0
530	108 - KSC - 386 -	48 / 76			NR-1	0
531	108 - KSC - 386 -	48 / 77			NR-1	0
532	108 - KSC - 386 -	48 / 78			NR-1	0
533	108 - KSC - 386 -	48 / 79			NR-1	0
534	108 - KSC - 386 -	48 / 80		SRB	NR-1, TGT 21-1	21
535	108 - KSC - 386 -	48 / 81		SRB	NR-1, TGT 21-1	21
536	108 - KSC - 386 -	48 / 82		SRB	NR-1, TGT 21-1	21
537	108 - KSC - 386 -	48 / 83		SRB	NR-1, TGT 21-1	21
538	108 - KSC - 386 -	48 / 89		SRB	NR-1, TGT 21-1	21
539	108 - KSC - 386 -	48 / 85		SRB	NR-1, TGT 21-1	21
540	108 - KSC - 386 -	48 / 86			NR-1	0

SORTED BY SRR NUMBER

UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
541	108 - KSC - 386 - 48 / 87			NR-1	0
542	108 - KSC - 386 - 48 / 89			NR-1	0
543	108 - KSC - 386 - 48 / 90		SRB	NR-1, AFT SKIRT FRAGMENT	0
544	108 - KSC - 386 - 48 / 92		SRB	NR-1, AFT SKIRT FRAGMENT	0
545	108 - KSC - 386 - 48 / 94		SRB	NR-1, AFT SKIRT FRAGMENT	0
546	108 - KSC - 386 - 48 / 98		SRB	NR-1, AFT SKIRT FRAGMENT	0
547	108 - KSC - 386 - 48 / 99		SRB	NR-1, AFT SKIRT FRAGMENT	0
548	108 - KSC - 386 - 48 / 107		SRB	NR-1, AFT SKIRT FRAGMENT	0
549	108 - KSC - 386 - 48 / 101		SRB	NR-1, AFT SKIRT FRAGMENT	0
550	108 - KSC - 386 - 48 / 102		SRB	NR-1, AFT SKIRT FRAGMENT	0
551	108 - KSC - 386 - 48 / 103		SRB	NR-1, AFT SKIRT FRAGMENT	0
552	108 - KSC - 386 - 48 / 104		SRB	NR-1, AFT SKIRT FRAGMENT	0
553	108 - KSC - 386 - 48 / 106		SRB	NR-1, HYD RES TVC FRAME	0
554	108 - KSC - 386 - 48 / 107		SRB	NR-1, FRAGMENT	0
555	108 - KSC - 386 - 48 / 109		SRB	NR-1, TVC FRAME	0
556	108 - KSC - 386 - 48 / 111		SRB	NR-1, NOZZLE FRAGMENT	0
557	108 - KSC - 386 - 48 / 113		SRB	NR-1, AFT SKIRT FRAGMENT	0
558	108 - KSC - 386 - 48 / 114		SRB	NR-1, AFT SKIRT STRUCTURE	0
559	108 - KSC - 386 - 48 / 115			NR-1, AFT SXIRT STRUCTURE	0
560	108 - KSC - 386 - 48 / 116			NR-1, FUEL SERVICE MODULE	0
561	108 - KSC - 386 - 48 / 120			NR-1, RING FRAGMENT	0
562	108 - KSC - 386 - 48 / 121			NR-1, RING FRAGMENT	0
563	108 - KSC - 386 - 48 / 122			NR-1, FRAGMENT	0
564	108 - KSC - 386 - 48 / 123			NR-1, FRAGMENT	0
565	108 - KSC - 386 - 48 / 124			NR-1, FRAGMENT	0
566	108 - KSC - 386 - 48 / 125			NR-1, FRAGMENT	0
567	108 - KSC - 386 - 48 / 126			NR-1, FRAGMENT	0
568	108 - KSC - 386 - 48 / 127			NR-1, FRAGMENT	0
569	108 - KSC - 386 - 48 / 129			NR-1, FRAGMENT	0
570	108 - KSC - 386 - 48 / 129			NR-1, FRAGMENT	0
571	108 - KSC - 386 - 48 / 130			NR-1, FRAGMENT	0
572	108 - KSC - 386 - 48 / 131			NR-1, FRAGMENT	0
573	108 - KSC - 386 - 48 / 132			NR-1, FRAGMENT	0
574	108 - KSC - 386 - 48 / 133			NR-1, FRAGMENT	0
575	108 - KSC - 386 - 48 / 139			NR-1, FRAGMENT	0
576	108 - KSC - 386 - 48 / 140			NR-1, FRAGMENT	0
577	108 - KSC - 386 - 48 / 141			NR-1, FRAGMENT	0
578	108 - KSC - 386 - 48 / 142			NR-1, FRAGMENT	0
579	108 - KSC - 386 - 48 / 152			NR-1, FRAGMENT	0
580	108 - KSC - 386 - 48 / 153			NR-1, FRAGMENT	0
581	108 - KSC - 386 - 48 / 156			NR-1, FRAGMENT	0
582	108 - KSC - 386C - 728 / 1			JSL II DIVES 1248 & 1249, UNDEFINABLE	0
583	108 - KSC - 386C - 728 / 2			JSL II DIVES 1248 & 1249, UNDEFINABLE	0
584	108 - KSC - 386C - 728 / 3			JSL II DIVES 1248 & 1249, UNDEFINABLE	0
585	108 - KSC - 386C - 734 / 17			NR-1	0
586	108 - KSC - 386C - 734 / 20			NR-1	0
587	108 - KSC - 386C - 734 / 29			NR-1	0
588	108 - KSC - 386C - 734 / 30			NR-1, SEA SHELL	0

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UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
589	108 - KSC - 386C - 734 / 31			NR-1	0
590	108 - KSC - 386C - 734 / 36			NR-1, DECK SHOT	0
591	108 - KSC - 386C - 734 / 67			NR-1, DECK SHOT	0
592	108 - KSC - 386C - 734 / 74			NR-1	0
593	108 - KSC - 386C - 734 / 83			NR-1	0
594	108 - KSC - 386C - 734 / 132			NR-1	0
595	108 - KSC - 386C - 734 / 105		SRB	NR-1, TGT 11	11
596	108 - KSC - 386C - 734 / 106		SRB	NR-1, TGT 11	11
597	108 - KSC - 386C - 734 / 107		SRB	NR-1, TGT 11	11
598	108 - KSC - 386C - 734 / 115		SRB	NR-1, TGT 11	11
599	108 - KSC - 386C - 734 / 126		SRB	NR-1, TGT 11	11
600	108 - KSC - 386C - 734 / 127		SRB	NR-1, TGT 11	11
601	108 - KSC - 386C - 734 / 129			NR-1	0
602	108 - KSC - 386C - 734 / 133			NR-1	0
603	108 - KSC - 386C - 734 / 134			NR-1	0
604	108 - KSC - 386C - 734 / 135			NR-1	0
605	108 - KSC - 386C - 734 / 141			NR-1	0
606	108 - KSC - 386C - 734 / 142			NR-1	0
607	108 - KSC - 386C - 734 / 143			NR-1	0
608	108 - KSC - 386C - 734 / 144			NR-1	0
609	108 - KSC - 386C - 734 / 145			NR-1	0
610	108 - KSC - 386C - 734 / 146			NR-1	0
611	108 - KSC - 386C - 734 / 147			NR-1	0
612	108 - KSC - 386C - 734 / 148			NR-1	0
613	108 - KSC - 386C - 734 / 149			NR-1	0
614	108 - KSC - 386C - 734 / 150			NR-1	0
615	108 - KSC - 386C - 734 / 152			NR-1	0
616	108 - KSC - 386C - 734 / 154			NR-1	0
617	108 - KSC - 386C - 734 / 155			NR-1	0
618	108 - KSC - 386C - 897 / 9 A			DEEP DRONE DIVES 34/36, OOC 8/9 (TAPES 083-084)	0
619	108 - KSC - 336C - 897 / 10 A			DEEP DRONE DIVES 34/36, OOC 8/9 (TAPES 083-084)	0
620	108 - KSC - 386C - 897 / 11 A			DEEP DRONE DIVES 34/36, OOC 8/9 (TAPES 083-084)	0
621	108 - KSC - 386C - 897 / 11 A			DEEP DRONE DIVES 34/36, OOC 8/9 (TAPES 083-084)	0
622	108 - KSC - 386C - 897 / 36 A			DEEP DRONE DIVES 34/36, OOC 8/9 (TAPES 083-084)	0
623	108 - KSC - 386C - 897 / 37 A			DEEP DRONE DIVE 34/36, OOC 8/9 (TAPES 083-084)	0
624	108 - KSC - 386C - 775 / 34			NR-1	0
625	108 - KSC - 386C - 775 / 35			NR-1	0
626	108 - KSC - 386C - 803 / 1			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
627	108 - KSC - 386C - 803 / 2				24
628	108 - KSC - 386C - 803 / 5			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
629	108 - KSC - 386C - 803 / 8			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
630	108 - KSC - 386C - 803 / 9			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24

SORTED BY SRR NUMBER

UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
631	108 - KSC - 386C - 803 /	10			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
632	108 - KSC - 386C - 803 /	11			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
633	108 - KSC - 386C - 803 /	12			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
634	108 - KSC - 386C - 803 /	13			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
635	108 - KSC - 386C - 803 /	14			JSL II DIVE 1259, TGT 24 (TAPES 068-069)	24
636	108 - KSC - 386C - 803 /	36			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
637	108 - KSC - 386C - 803 /	37			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
638	108 - KSC - 386C - 803 /	38			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
639	108 - KSC - 386C - 803 /	39			JSL II DIVE #1259, TGT 24 (068-070)	24
640	108 - KSC - 386C - 803 /	40			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
641	108 - KSC - 386C - 803 /	41			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
642	108 - KSC - 386C - 803 /	42			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
643	108 - KSC - 386C - 803 /	43			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
644	108 - KSC - 386C - 803 /	44			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
645	108 - KSC - 386C - 804 /	12 A			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
646	108 - KSC - 386C - 804 /	13 A			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
647	108 - KSC - 386C - 804 /	15			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
648	108 - KSC - 386C - 804 /	16			JSL II DIVE 1259, TGT 24 (TAPES 068-070)	24
649	108 - KSC - 386C - 804 /	17			JSL II DIVE 1259 TGT 24 (TAPES 068-070)	24
650	108 - KSC - 386C - 872 /	4 A			NON-SHUTTLE	0
651	108 - KSC - 386C - 872 /	7 A			DEEP DRONE DIVES 32 & 33, OOC CONTACTS 3 & 4 (TAPES 081-082)	0
652	108 - KSC - 386C - 872 /	9 A			DEEP DRONE DIVES 32 & 33, OOC CONTACTS 4 TGT 1&2 AND OOC CONTACT 3 TGT 1&2 (TAPES 081-082)	0
653	108 - KSC - 386C - 872 /	14 A			DEEP DRONE DIVES 32 & 33, OOC CONTACT #4 TGT 1 & 2, OOC CONTACT #3 TGT 1 & 2 (TAPES 081-082)	0
654	108 - KSC - 386C - 872 /	15 A			DEEP DRONE DIVES 32 & 33, OOC CONTACTS #4 TGT 1 & 2, OOC CONTACT #3 TGT 1 & 2 (TAPES 081-082)	0
655	108 - KSC - 386C - 872 /	16 A			DEEP DRONE DIVES 32 & 33, OOC CONTACT 4 TGT 1 & 2, OOC CONTACT 3 TGT 1 & 2 (TAPES 081-082)	0
656	108 - KSC - 386C - 872 /	17 A			DEEP DRONE DIVES 32 & 33, OOC CONTACT 4 TGT 1 & 2, OOC CONTACT 3 TGT 1&2 (TAPES 081-082)	0
657	108 - KSC - 386C - 872 /	28 A			DEEP DRONE DIVES 32 & 33, OOC CONTACT 4 TGT 1 & 2, OOC CONTACT 3 TGT 1&2 (TAPES 081-082)	0
658	108 - KSC - 386C - 872 /	29 A			DEEP DRONE DIVES 32 & 33, OOC CONTACTS 4, TGT 1 & 2, OOC CONTACT 3, TGT 1 & 2 (TAPES 081 & 082)	0
659	108 - KSC - 386C - 872 /	35 A			DEEP DRONE DIVE 37 & 33, OOC #3, TGS 1 & 2 (TAPES 081 & 082)	0
660	108 - KSC - 386C - 897 /	39 A			DEEP DRONE DIVE 34/36, OOC CONTACT 8/9 (TAPES 083-084)	0
661	108 - KSC - 386C - 903 /	1	086		JSL II DIVE 127, OOC #301	301

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UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
662	108 - KSC - 386C - 903 /	2	086		JSL II DIVE 127, OOC #301	301
663	108 - KSC - 386C - 903 /	3	086		JSL II DIVE 127, OOC #301	301
664	108 - KSC - 386C - 903 /	35	086		JSL II DIVE 127, OOC #301	301
665	108 - KSC - 386C - 903 /	36	086		JSL II DIVE 127, OOC #301	301
666	108 - KSC - 386C - 903 /	37	086		JSL II DIVE 127, OOC #301	301
667	108 - KSC - 386C - 903 /	38	086		JSL II DIVE 127, OOC #301	301
668	108 - KSC - 386C - 903 /	39	086		JSL II DIVE 127, OOC #301	301
669	108 - KSC - 386C - 903 /	40	086		JSL II DIVE 127, OOC #301	301
670	108 - KSC - 386C - 903 /	41	086		JSL II DIVE 127, OOC #301	301
671	108 - KSC - 386C - 903 /	42	086		JSL II DIVE 127, OOC #301	301
672	108 - KSC - 386C - 903 /	43	086		JSL II DIVE 127, OOC #301	301
673	108 - KSC - 386C - 903 /	44			JSL II DIVE 127, OOC #301	301
674	108 - KSC - 386C - 910 /	19			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
675	108 - KSC - 386C - 910 /	20			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
676	108 - KSC - 386C - 910 /	21			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
677	108 - KSC - 386C - 910 /	22			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
678	108 - KSC - 386C - 910 /	23			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
679	108 - KSC - 386C - 910 /	34			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
680	108 - KSC - 386C - 910 /	35			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087 & 088)	0
681	108 - KSC - 386C - 910 /	37			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
682	108 - KSC - 386C - 910 /	38			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
683	108 - KSC - 386C - 910 /	43			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088), OLD BARRELL?	0
684	108 - KSC - 386C - 910 /	44			DEEP DRONE DIVES 39 & 41, OOC 23, 214, 209 (TAPES 087-088)	0
685	108 - KSC - 386C - 923 /	3 A			DEEP DRONE DIVE #52 (TAPES 096-097)	191
686	108 - KSC - 386C - 923 /	4 A			DEEP DRONE DIVE #52 (TAPES 096-097)	191
687	108 - KSC - 386C - 923 /	5 A			DEEP DRONE DIVE #52 (TAPES 096-097)	191
688	108 - KSC - 386C - 923 /	6 A			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
689	108 - KSC - 386C - 923 /	7 A			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
690	108 - KSC - 386C - 923 /	29			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
691	108 - KSC - 386C - 923 /	30			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
692	108 - KSC - 386C - 923 /	31			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
693	108 - KSC - 386C - 923 /	34			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191

SORTED B NUMBER

UNDERWATER PHOTO LIBRARY

SRR NUMBER	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
694	108 - KSC - 386C	- 923 / 40			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
695	108 - KSC - 386C	- 923 / 41			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
696	108 - KSC - 386C	- 923 / 42			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
697	108 - KSC - 386C	- 923 / 43			DEEP DRONE DIVE #52 (TAPES 096-097), NON SHUTTLE	191
698	108 - KSC - 386C	- 921 / 14	090	SRB	JSL II DIVE 1281, TANG (FACTORY JOINT) AND FIELD JOINT CLEVIS	195
699	108 - KSC - 386C	- 921 / 15	090	SRB	JSL II DIVE 1281, CONTACT 195	195
700	108 - KSC - 386C	- *** / 28	086	SRB	GEMINI DIVE #33, RH FWD AFT CYL	301
701	108 - KSC - 386C	- *** / 27	086	SRB	GEMINI DIVE #33, RH FWD AFT CYL	301
702	108 - KSC - 386C	- *** / 26	086	SRB	GEMINI DIVE #33, RH FWD AFT CYL	301
703	108 - KSC - 386C	- *** / 25	086	SRB	GEMINI DIVE #33, RH FWD AFT CYL	301
704	108 - KSC - 386C	- *** / 36	086	SRB	GEMINI DIVE #33, RH FWD AFT CYL	301
705	108 - KSC - 386C	- *** / 20	113	SRB	JSL II DIVE 1294, CONTACT 615-1	615
706	108 - KSC - 386C	- 937 / 10	100	TDRS	DEEP DRONE DIVE #54	192
707	108 - KSC - 386C	- 937 / 11	100	TDRS	DEEP DRONE DIVE #54	192
708	108 - KSC - 386C	- 937 / 12	100	TDRS	DEEP DRONE DIVE 54	192
709	108 - KSC - 386C	- 937 / 13	100	TDRS	DEEP DRONE DIVE #54	192
710	108 - KSC - 386C	- 937 / 14	100	TDRS	DEEP DRONE DIVE #54	192
711	108 - KSC - 386C	- 937 / 18	100	TDRS	DEEP DRONE DIVE #54	192
712	108 - KSC - 386C	- 937 / 19	100	TDRS	DEEP DRONE DIVE #54	192
713	108 - KSC - 386C	- 937 / 21	100	TDRSS	DEEP DRONE DIVE #54	192
714	108 - KSC - 386C	- 937 / 22	100	TDRS	DEEP DRONE DIVE #54	192
715	108 - KSC - 386C	- *** / 25		SRB	JSL DIVE #1306	0
716	108 - KSC - 386C	- *** / 26		SRB	JSL	0
717	108 - KSC - 386C	- *** / 27				0
718	108 - KSC - 386C	- *** / 30				0
719	108 - KSC - 386C	- *** / 31		SRB	JSL DIVE #1306	0
720	108 - KSC - 386C	- *** / 36		SRB	JSL DIVE #1306	0
721	108 - KSC - 386C	- *** / 37		SRB	JSL II DIVE #1306	0
722	108 - KSC - 386C	- *** / 38 A		SRB	JSL II DIVE #1306	0
723	108 - KSC - 386C	- *** / 39 A		SRB	JSL II DIVE #1306	0
724	108 - KSC - 386C	- *** / 40 A		SRB	JSL II DIVE #1306	0
725	108 - KSC - 386C	- *** / 41 A		SRB	JSL II DIVE #1306	0
726	108 - KSC - 386C	- *** / 9 A		SRB	JSL II DIVE #1306	0
727	108 - KSC - 386C	- *** / 10 A		SRB	JSL II DIVE #1306	0
728	108 - KSC - 386C	- *** / 11 A		SRB	JSL II DIVE #1306	0
729	108 - KSC - 386C	- *** / 12 A		SRB	JSL II DIVE #1306	0
730	108 - KSC - 386C	- *** / 13 A		SRB	JSL II DIVE #1306	0
731	108 - KSC - 386C	- *** / 19 A		SRB	JSL II DIVE #1306	0
732	108 - KSC - 386C	- *** / 30 A		SRB	JSL II DIVE #1306	0
733	108 - KSC - 386C	- *** / 31 A		SRB	JSL II DIVE #1306	0
734	108 - KSC - 386C	- *** / 32 A		SRB	JSL II DIVE #1306	0
735	108 - KSC - 386C	- *** / 33 A		SRB	JSL II DIVE #1306	0
736	108 - KSC - 386C	- *** / 35 A		SRB	JSL II DIVE #1306	0

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   SRR         PHOTO          #              TAPE        SYSTEM        COMMENTS                                              OOC #
NUMBER                                      NUMBER
                                                                                                                            TARGET
                                                                                                                            NUMBER

    737     108 - KSC - 386C - *** /   36 A                SRB         JSL II DIVE #1306                                         0
    738     108 - KSC - 386C - *** /   37 A                SRB         JSL II DIVE #1306                                         0
    739     108 - KSC - 386C - *** /   38 A                SRB         JSL II DIVE #1306                                         0
    740     108 - KSC - 386C - *** /   39 A                SRB         JSL II DIVE #1306                                         0
    741     108 - KSC - 386C - *** /   40 A                SRB         JSL II DIVE #1306                                         0
    742     108 - KSC - 386C - *** /   41 A                SRB         JSL II DIVE #1306                                         0
    743     108 - KSC - 386C - *** /   42 A                SRB         JSL II DIVE #1306                                         0
    744     108 - KSC - 386C - *** /   43 A                SRB         JSL II DIVE #1306                                         0
    746     108 - KSC - 386C - *** /   44 A                SRB         JSL II DIVE #1306                                         0
    747     108 - KSC - 386C - *** /    1 A                SRB         JSL II DIVE #1306                                         0
    748     108 - KSC - 386C - *** /    2 A                SRB         JSL II DIVE #1306                                         0
    749     108 - KSC - 386C - *** /    3 A                SRB         JSL II DIVE #1306                                         0
    750     108 - KSC - 386C - *** /    4 A                SRB         JSL II DIVE #1306                                         0
    751     108 - KSC - 386C - *** /   29                  SRB         DEEP DRONE DIVE #96, OOC CONTACT #22-1                    0
    752     108 - KSC - 386C - *** /   30                  SRB         DEEP DRONE DIVE #96, OOC CONTACT #22-1                    0
    753     108 - KSC - 386C - *** /   31                  SRB         DEEP DRONE DIVE #96, OOC CONTACT #22-1                    0
    754     108 - KSC - 386C - *** /    3                  SRB                                                                   0
    755     108 - KSC - 386C - *** /    5 A                SRB         GEMINI DIVE #46-56, CONTACT #21                           0
    756     108 - KSC - 386C - *** /    8                  SRB         GEMINI CONTACT #21,  DIVE #46-56                          0
    757     108 - KSC - 386C - *** /   10 A                SRB         GEMINI CONTACT #21, DIVE #46-56                           0
    758     108 - KSC - 386C - *** /   23                  SRB         GEMINI CONTACT #21, DIVE #46-56                           0
    759     108 - KSC - 386C - *** /   25                  SRB         GEMINI CONTACT #21, DIVE #46-56                           0
    760     108 - KSC - 386C - *** /   28                  SRB         GEMINI CONTACT #21, DIVE #46-56                           0
    761     108 - KSC - 386C - *** /   31                  SRB         GEMINI CONTACT #21, DIVE #46-56                           0
    762     108 - KSC - 386C - *** /   33 A                SRB         GEMINI DIVE #46-56                                       21
    763     108 - KSC - 386C - *** /   36 A                SRB         GEMINI DIVE #46-56                                       21
    764     108 - KSC - 386C - *** /   23 A                SRB         GEMINI DIVE #21                                          21
    765     108 - KSC - 386C - *** /   39                  SRB         GEMINI DIVE #46-56                                       21
    766     108 - KSC - 386C - *** /   10                  SRB         GEMINI DIVE #46-56                                       21
    767     108 - KSC - 386C - *** /   12                  SRB         GEMINI DIVE #46-56                                       21
    768     108 - KSC - 386C - *** /   15 A                SRB         GEMINI DIVE #46-56                                       21
    769     108 - KSC - 386C - *** /   18                  SRB                                                                  21
    770     108 - KSC - 386C - *** /   20 A                SRB         GEMINI DIVE #46-56                                       21
    771     108 - KSC - 386C - *** /   23 A                SRB         GEMINI DIVE #46-56                                       21
    772     108 - KSC - 386C - *** /   25 A                SRB         GEMINI DIVE #46-56                                       21
    773     108 - KSC - 386C - *** /   28 A                SRB         GEMINI DIVE #46-56                                       21
    774     108 - KSC - 386C - *** /   31                  SRB         GEMINI DIVE #46-56                                       21
    775     108 - KSC - 386C - *** /   33 A                SRB         GEMINI DIVE #46-56                                       21
    776     108 - KSC - 386C - *** /   36 A                SRB         GEMINI DIVE #46-56                                       21
    777     108 - KSC - 386C - *** /   39                  SRB                                                                  21
    778     108 - KSC - 386C - *** /   41 A                SRB         GEMINI DIVE #46-56                                       21
    779     108 - KSC - 386C - *** /   44                  SRB         GEMINI DIVE #46-56                                       21
    780     108 - KSC - 386C - *** /   10 A                SRB         GEMINI DIVE #46-56                                       21
    781     108 - KSC - 386C - *** /   13                  SRB         GEMINI DIVE #46-56                                       21
    783     108 - KSC - 386C - *** /   10 A                SRB         GEMINI DIVE #46-56                                       21
    784     108 - KSC - 386C - *** /   13 A                SRB         GEMINI DIVE #46-56                                       21
    785     108 - KSC - 386C - *** /   16 A                SRB         GEMINI DIVE #46-56                                       21
    786     108 - KSC - 386C - *** /   18 A                SRB         GEMINI DIVE #46-56                                       21
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SRB NUMBER	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	OOC # TARGET NUMBER
787	108 - KSC - 386C - *** / 21 A		SRB	GEMINI DIVE #46-56	21
788	108 - KSC - 386C - *** / 24		SRB	GEMINI DIVE #46-56	21
789	108 - KSC - 386C - *** / 41 A		SRB	GEMINI DIVE #46-56	21
790	108 - KSC - 386C - *** / 44		SRB	GEMINI DIVE #46-56	21
791	108 - KSC - 386C - *** / 3		SRB	GEMINI DIVE #46-56	21
792	108 - KSC - 386C - *** / 5 A		SRB	GEMINI DIVE #46-56	21
794	108 - KSC - 386C - *** / 10 A		SRB	GEMINI DIVE #46-56	21
795	108 - KSC - 386C - *** / 1		SRB	GEMINI DIVE #44	21
796	108 - KSC - 386C - *** / 2		SRB	GEMINI DIVE #44	21
797	108 - KSC - 386C - *** / 3		SRB		21
798	108 - KSC - 386C - *** / 4		SRB	GEMINI DIVE #44	21
799	108 - KSC - 386C - *** / 5		SRB	GEMINI DIVE #44	21
800	108 - KSC - 386C - *** / 6		SRB	GEMINI DIVE #44	21
801	108 - KSC - 386C - *** / 7		SRB	GEMINI DIVE #44	21
802	108 - KSC - 386C - *** / 8		SRB	GEMINI DIVE #44	21
803	108 - KSC - 386C - *** / 9		SRB	GEMINI DIVE #44	21
804	108 - KSC - 386C - *** / 10		SRB	GEMINI DIVE #44	21
805	108 - KSC - 386C - *** / 11		SRB	GEMINI DIVE #44	21
806	108 - KSC - 386C - *** / 12		SRB	GEMINI DIVE #44	21
807	108 - KSC - 386C - *** / 13		SRB	GEMINI DIVE #44	21
808	108 - KSC - 386C - *** / 14		SRB	GEMINI DIVE #44	21
809	108 - KSC - 386C - *** / 15		SRB		0
810	108 - KSC - 386C - *** / 1		SRB		0
811	108 - KSC - 386C - *** / 2		SRB		0
812	108 - KSC - 386C - *** / 3		SRB		0
813	108 - KSC - 386C - *** / 4		SRB		0
814	108 - KSC - 386C - *** / 5		SRB		0
815	108 - KSC - 386C - *** / 6		SRB		0
816	108 - KSC - 386C - *** / 7		SRB		0
817	108 - KSC - 386C - *** / 8		SRB		0
818	108 - KSC - 386C - *** / 9		SRB		0
819	108 - KSC - 386C - *** / 10		SRB		0
820	108 - KSC - 386C - *** / 11		SRB	821	0
821	108 - KSC - 386C - *** / 12		SRB		0
822	108 - KSC - 386C - *** / 15		SRB		0
823	108 - KSC - 386C - *** / 14		SRB		0
824	108 - KSC - 386C - *** / 3		SRB		0
825	108 - KSC - 386C - *** / 6		SRB		0
826	108 - KSC - 386C - *** / 17		SRB		0
827	108 - KSC - 386C - *** / 18		SRB		0
828	108 - KSC - 386C - *** / 19		SRB		0
829	108 - KSC - 386C - *** / 2		SRB		0
830	108 - KSC - 386C - *** / 21		SRB	NONSHUTTLE	0
831	108 - KSC - 386C - *** / 22		SRB		0
832	108 - KSC - 386C - *** / 23		SRB		0
833	108 - KSC - 386C - *** / 24		SRB		0
834	108 - KSC - 386C - *** / 25		SRB		0
835	108 - KSC - 386C - *** / 26		SRB		0

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  SRR        PHOTO          #            TAPE       SYSTEM      COMMENTS                                         OOC #
NUMBER         .                        NUMBER
                                                                                                                  TARGET
                                                                                                                  NUMBER

   836    108 - KSC - 386C - *** /  27                SRB                                                            0
   837    108 - KSC - 386C - *** /  28                SRB                                                            0
   838    108 - KSC - 386C - *** /  29                SRB                                                            0
   839    108 - KSC - 386C - *** /  30                SRB                                                            0
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APPENDIX C
List of Recovery Photographs

As part of the Search, Recovery and Reconstruction Team effort, a library of Underwater Recovery Photographs was maintained. Once a photograph was taken, copies were provided to JSC, MSFC, and the Supervisor of Salvage, USN. The master photograph was kept in the data viewing area, Room 2174, Headquarters Building, KSC.

A Team photo number plus the KSC photo number was entered into a personal computer data base system. This Appendix C is a list of all Recovery Photographs logged into the data base as of close of business, May 5, 1986.

Recovery photographs were taken during recovery operations. Views are largely of interest to salvage operations and tend to document possible methods for rigging the item for retrieval.

	SRR NUMB	PHOTO	#		TAPE NUMBER	SYSTEM	COMMENTS	ODC TARGET NUMBER
R	0	108 - KSC - 386C -	0 /	0				0
R	1001	108 - KSC - 386C -	902 /	1	R4	SRB	ON BOARD STENA. VIEW DOES NOT INCLUDE 51-L HARDWARE	11
R	1002	108 - KSC - 386C -	902 /	2	R4	SRB	ON BOARD STENA. VIEW DOES NOT INCLUDE 51-L HARDWARE	0
R	1003	108 - KSC - 386C -	902 /	10	R4	SRB	RETRIEVAL. LEFT SRB. STENA WORKHORSE	11
R	1004	108 - KSC - 386C -	902 /	11	R4	SRB	RETRIEVAL. LEFT SRB. STENA WORKHORSE	11
R	1005	108 - KSC - 386C -	902 /	12	R4	SRB	LEFT SRB PIECE. STENA WORKHORSE RETRIEVAL. END VIEW	11
R	1006	108 - KSC - 386C -	902 /	13	R4	SRB	LEFT SRB PIECE. RETRIEVAL. STENA. END VIEW	11
R	1007	108 - KSC - 386C -	902 /	14	R4	SRB	LEFT SRB PIECE. CLOSE-UP	11
R	1008	108 - KSC - 386C -	902 /	15			GEMINI DIVES 14. 15. 16. 18. VIEW DOES NOT INCLUDE 51-L HARDWARE	0
R	1009	108 - KSC - 386C -	925 /	43			GEMINI DIVES 14. 15. 16. 18	0
R	1010	108 - KSC - 386C -	925 /	38			GEMINI DIVES 14. 15. 16. 18	0
R	1011	108 - KSC - 386C -	925 /	37			GEMINI DIVES 14. 15. 16. 18	0
R	1012	108 - KSC - 386C -	925 /	39 A			GEMINI DIVES 14. 15. 16. 18	0
R	1013	108 - KSC - 386C -	925 /	40 A			GEMINI DIVES 14. 15. 16. 18	0
R	1014	108 - KSC - 386C -	925 /	42			GEMINI DIVES 14. 15. 16. 18	0
R	1015	108 - KSC - 386C -	925 /	35 A			GEMINI DIVES 14. 15. 16. 18	0
R	1016	108 - KSC - 386C -	958 /	10 A			GEMINI DIVES 14. 15. 16. 18. ATTACHING TOOL TO DEBRIS	0
R	1016	108 - KSC - 386C -	958 /	10 A			GEMINI DIVES 14. 15. 16. 18	0
R	1017	108 - KSC - 386C -	958 /	12			GEMINI DIVES 14. 15. 17. 18	0
R	1018	108 - KSC - 386C -	958 /	18	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1019	108 - KSC - 386C -	958 /	19 A	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1020	108 - KSC - 386C -	958 /	20 A	R2		GEMINI DIVES 14. 15. 16.18	0
R	1021	108 - KSC - 386C -	958 /	22 A	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1022	108 - KSC - 386C -	958 /	23	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1024	108 - KSC - 386C -	958 /	25 A	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1025	108 - KSC - 386C -	958 /	27 A	R2		GEMINI DIVES 14. 15. 16. 18	0
R	1026	108 - KSC - 386C -	958 /	28 A				0
R	1027	108 - KSC - 386C -	958 /	30			GEMINI DIVES 14. 15. 16. 18	0
R	1028	108 - KSC - 386C -	958 /	31			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1029	108 - KSC - 386C -	958 /	32 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1030	108 - KSC - 386C -	958 /	33 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1031	108 - KSC - 386C -	958 /	35 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1032	108 - KSC - 386C -	958 /	36 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1033	108 - KSC - 386C -	958 /	37 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1034	108 - KSC - 386C -	958 /	38 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0
R	1035	108 - KSC - 386C -	958 /	40 A			GEMINI DIVES 14. 15. 16. 18. LIFTING CABLE ATTACHED	0

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	SRR NUMB	PHOTO	#		TAPE NUMBER	SYSTEM	COMMENTS	OOC TARGET NUMBER
R	1036	108 - KSC - 386C -	958 /	41	R2		GEMINI DIVES 14, 15, 16, 18, LIFTING CABLE ATTACHED	0
R	1037	108 - KSC - 386C -	958 /	43	R2		GEMINI DIVES 14, 15, 16, 18, LIFTING CABLE ATTACHED	0
R	1038	108 - KSC - 386C -	958 /	44			GEMINI DIVES 14, 15, 16, 18, LIFTING CABLE ATTACHED	0
R	1039	108 - KSC - 386C -	957 /	37 A			GEMINI DIVES 14, 15, 16, 18, VIEW DOES NOT INCLUDE 51-L HARDWARE	0
R	1040	108 - KSC - 386C -	957 /	36			GEMINI DIVES 14, 15, 16, 18	0
R	1041	108 - KSC - 386C -	957 /	35			GEMINI DIVES 14, 15, 16, 18	0
R	1042	108 - KSC - 386C -	957 /	32 A			GEMINI DIVES 14, 15, 16, 18	0
R	1043	108 - KSC - 386C -	957 /	30			GEMINI DIVES 14, 15, 16, 18	0
R	1044	108 - KSC - 386C -	957 /	28			GEMINI DIVES 14, 15, 16, 18	0
R	1045	108 - KSC - 386C -	957 /	19			GEMINI DIVES 14, 15, 17, 18	0
R	1046	108 - KSC - 386C -	957 /	17 A			GEMINI DIVES 14, 15, 16, 18	0
R	1047	108 - KSC - 386C -	957 /	16 A	R2		GEMINI DIVES 14, 15, 16, 18	0
R	1048	108 - KSC - 386C -	957 /	15			GEMINI DIVES 14, 15, 16, 18	0
R	1049	108 - KSC - 386C -	957 /	14			GEMINI DIVES 14, 15, 16, 18	0
R	1050	108 - KSC - 386C -	957 /	12 A	R2		GEMINI DIVES 14, 15, 16, 18	0
R	1051	108 - KSC - 386C -	957 /	11 A			GEMINI DIVES 14, 15, 16, 18	0
R	1052	108 - KSC - 386C -	957 /	9 A	R2		GEMINI DIVES 14, 15, 16, 18	26
R	1053	108 - KSC - 386C -	957 /	6	R2		GEMINI DIVES 14, 15, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220	26
R	1054	108 - KSC - 386C -	957 /	4 A	R2		GEMINI DIVES 14, 15, 16, 18, OOC CONTACT 26-1, 26-2, 218, 219 AND 220	26
R	1055	108 - KSC - 386C -	957 /	3	R2		GEMINI DIVES 14, 15, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220	26
R	1056	108 - KSC - 386C -	957 /	2	R2		GEMINI DIVES 14, 15, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220	26
R	1057	108 - KSC - 386C -	959 /	1	R2		GEMINI DIVES 14, 15, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220	26
R	1058	108 - KSC - 386C -	959 /	1 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1059	108 - KSC - 386C -	959 /	2 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1060	108 - KSC - 386C -	959 /	4 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1061	108 - KSC - 386C -	959 /	5 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1062	108 - KSC - 386C -	959 /	7	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1063	108 - KSC - 386C -	959 /	8	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1064	108 - KSC - 386C -	959 /	9 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1065	108 - KSC - 386C -	959 /	10 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1066	108 - KSC - 386C -	959 /	12	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26

	SRR NUMB	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC TARGET NUMBER
R	1067	108 - KSC - 386C -	959 / 13	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1068	108 - KSC - 386C -	959 / 16	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1069	108 - KSC - 386C -	959 / 16	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1070	108 - KSC - 386C -	959 / 17 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1071	108 - KSC - 386C -	959 / 18 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1072	108 - KSC - 386C -	959 / 20	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1073	108 - KSC - 386C -	959 / 21	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1074	108 - KSC - 386C -	959 / 22 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1075	108 - KSC - 386C -	959 / 23 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1076	108 - KSC - 386C -	959 / 25 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1077	108 - KSC - 386C -	959 / 26 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1078	108 - KSC - 386C -	959 / 28	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1079	108 - KSC - 386C -	959 / 29	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1080	108 - KSC - 386C -	959 / 30 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1081	108 - KSC - 386C -	959 / 31 A	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1082	108 - KSC - 386C -	959 / 33	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1083	108 - KSC - 386C -	959 / 34	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1084	108 - KSC - 386C -	959 / 36	R2		GEMINI DIVES 14, 14, 16, 18, OOC CONTACTS 26-1, 26-2, 218, 219 AND 220, LIFTING TOOL ATTACHED	26
R	1085	108 - KSC - 386C -	918 / 9	R3		GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1086	108 - KSC - 386C -	918 / 10			GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1087	108 - KSC - 386C -	918 / 11			GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1088	108 - KSC - 386C -	918 / 12			GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1089	108 - KSC - 386C -	918 / 13			GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1090	108 - KSC - 386C -	918 / 14			GEMINI DIVE #17, VIEW DOES NOT INCLUDE 51-L HARDWARE	218

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	SRR NUMB	PHOTO #	TAPE NUMBER	SYSTEM	COMMENTS	ODC TARGET NUMBER
R	1091	108 - KSC - 386C - 918 / 15			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1092	108 - KSC - 386C - 918 / 16			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1093	108 - KSC - 386C - 918 / 22			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1094	108 - KSC - 386C - 918 / 23	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1095	108 - KSC - 386C - 918 / 24	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1096	108 - KSC - 386C - 918 / 25	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1097	108 - KSC - 386C - 918 / 26	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1098	108 - KSC - 386C - 918 / 27	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1099	108 - KSC - 386C - 918 / 28	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1100	108 - KSC - 386C - 918 / 29	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1101	108 - KSC - 386C - 918 / 30	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1102	108 - KSC - 386C - 918 / 31	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1103	108 - KSC - 386C - 918 / 32	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1104	108 - KSC - 386C - 918 / 33	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1105	108 - KSC - 386C - 918 / 35	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1105	108 - KSC - 386C - 918 / 34	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1106	108 - KSC - 386C - 918 / 36	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1107	108 - KSC - 386C - 918 / 37	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1108	108 - KSC - 386C - 918 / 38	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1109	108 - KSC - 386C - 918 / 39	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1110	108 - KSC - 386C - 918 / 40	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1111	108 - KSC - 386C - 918 / 41	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1112	108 - KSC - 386C - 918 / 42	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1113	108 - KSC - 386C - 918 / 43	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218

	SRR NUMB	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC TARGET NUMBER
R	1114	108 - KSC - 386C - 918 /	44	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1115	108 - KSC - 386C - 918 /	45	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1116	108 - KSC - 386C - 918 /	46	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1117	108 - KSC - 386C - 918 /	47	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	0
R	1118	108 - KSC - 386C - 918 /	48	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1119	108 - KSC - 386C - 918 /	49	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1120	108 - KSC - 386C - 918 /	50	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1121	108 - KSC - 386C - 918 /	51	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1122	108 - KSC - 386C - 918 /	52	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1123	108 - KSC - 386C - 918 /	53	R3		GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1124	108 - KSC - 386C - 918 /	54			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1125	108 - KSC - 386C - 918 /	55			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1126	108 - KSC - 386C - 918 /	3			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1127	108 - KSC - 386C - 918 /	4			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1128	108 - KSC - 386C - 918 /	2			GEMINI DIVE #17. VIEW DOES NOT INCLUDE 51-L HARDWARE	218
R	1129	108 - KSC - 386C - 1921 /	0		SRB	STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1130	108 - KSC - 386C - 1921 /	1		SRB	STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1131	108 - KSC - 386C - 1921 /	2			STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1132	108 - KSC - 386C - 1921 /	3			STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1133	108 - KSC - 386C - 1921 /	4			STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1134	108 - KSC - 386C - 1921 /	5			STENA WORKHORSE RECOVERY CTR SEG-FWD CYL	195
R	1135	108 - KSC - 386C - 1921 /	6			CLOSE-UP VIEW CONTACT 195	195
R	1136	108 - KSC - 386C - 1921 /	7			CLOSE-UP VIEW CONTACT 195	195
R	1137	108 - KSC - 386C - 1921 /	8			ON STENA WORKHORSE. CLOSE-UP VIEW. CONTACT 195	195
R	1138	108 - KSC - 386C - 1921 /	9			ON STENA WORKHORSE. CLOSE-UP VIEW. CONTACT 195	195
R	1139	108 - KSC - 386C - 1921 /	10			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1140	108 - KSC - 386C - 1921 /	11			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1141	108 - KSC - 386C - 1921 /	12			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1142	108 - KSC - 386C - 1921 /	13			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1143	108 - KSC - 386C - 1921 /	14			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1144	108 - KSC - 386C - 1921 /	15			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1145	108 - KSC - 386C - 1921 /	16			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1146	108 - KSC - 386C - 1921 /	17			CLOSE-UP VIEW CONTACT 195. RECOVERED	195

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	SRR NUMB	PHOTO	#	TAPE NUMBER	SYSTEM	COMMENTS	OOC TARGET NUMBER
R	1147	108 - KSC - 386C - 1921 /	18			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1148	108 - KSC - 386C - 1921 /	19			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1149	108 - KSC - 386C - 1921 /	20			CLOSE-UP VIEW CONTACT 195. RECOVERED	195
R	1150	108 - KSC - 386C - 1921 /	21			ON BOARD STENA	195
R	1151	108 - KSC - 386C - 1921 /	22			ON BOARD STENA	195
R	1152	108 - KSC - 386C - 1921 /	23			CLOSE-UP VIEW CONTACT 195	195
R	1153	108 - KSC - 386C - 1921 /	24			CLOSE-UP VIEW CONTACT 195	195
R	1154	108 - KSC - 386C - 1921 /	25			CLOSE-UP VIEW CONTACT 195	195
R	1155	108 - KSC - 386C - 1922 /	1		SRB	RH FWD SEGMENT - AFT CYL RECOVERY	301
R	1156	108 - KSC - 386C - 1922 /	2		SRB	RH FWD SEGMENT - AFT CYL RECOVERY	301
R	1157	108 - KSC - 386C - 1922 /	3		SRB	RH FWD SEGMENT - AFT CYL RECOVERY	301
R	1158	108 - KSC - 386C - 1922 /	4		SRB	RH FWD SEGMENT - AFT CYL RECOVERY	301
R	1159	108 - KSC - 386C - 1922 /	5			RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1160	108 - KSC - 386C - 1922 /	6		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1161	108 - KSC - 386C - 1922 /	7		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1162	108 - KSC - 386C - 1922 /	8		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1163	108 - KSC - 386C - 1922 /	9		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1164	108 - KSC - 386C - 1922 /	10		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1165	108 - KSC - 386C - 1922 /	11		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1166	108 - KSC - 386C - 1922 /	12		SRB	RH FWD/AFT CYL. STENA WORKHORSE. CLOSE-UP VIEW	301
R	1167	108 - KSC - 386C - 1922 /	13		SRB	RH FWD/AFT CYL. STENA WORKHORSE	301
R	1168	108 - KSC - 386C - 1922 /	14		SRB	RH FWD/AFT CYL. STENA	301
R	1169	108 - KSC - 386C - 1922 /	15		SRB	RH FWD/AFT CYL. STENA	301
R	1170	108 - KSC - 386C - 1923 /	0 X		SRB	RH AFT SEG - ET ATTACH ON BOARD	292
R	1171	108 - KSC - 386C - 1923 /	0			RIGHT AFT ETA PIECE ON CARGO DECK. STENA WORKHORSE	292
R	1172	108 - KSC - 386C - 1923 /	3			RIGHT AFT ETA ON CARGO DECK. STENA WORKHORSE	292
R	1173	108 - KSC - 386C - 1923 /	2		SRB	RIGHT AFT ETA PIECE ON CARGO DECK STENA WORKHORSE	292
R	1174	108 - KSC - 386C - 1923 /	3		SRB	RIGHT AFT ETA ON CARGO DECK. STENA WORKHORSE	292
R	1175	108 - KSC - 386C - 1923 /	4			RIGHT AFT SEG ATTACH	292
R	1176	108 - KSC - 386C - 1923 /	5		SRB	RIGHT AFT SEG ATTACH	292
R	1177	108 - KSC - 386C - 1923 /	6		SRB	OOC #293 BEING OFFLOADED	292
R	1178	108 - KSC - 386C - 1923 /	7		SRB	RIGHT AFT SEG ATTACH	292
R	1179	108 - KSC - 386C - 1923 /	8			RIGHT AFT ETA PIECE IN HOLDING TANK. STENA WORKHORSE	292
R	1180	108 - KSC - 386C - 1923 /	9		SRB		292
R	1181	108 - KSC - 386C - 880 /	5	R5	SRB	LEFT SRB. FIRST PIECE RETRIEVAL #11	11
R	1182	108 - KSC - 386C - 880 /	6	R5	SRB	LEFT SRB. FIRST PIECE RETRIEVAL #11	11
R	1183	108 - KSC - 386C - 880 /	13	R5	SRB	LEFT SRB. FIRST PIECE RETREIVAL #11	11
R	1184	108 - KSC - 386C - 880 /	15	R5	SRB	LEFT SRB. FIRST PIECE RETRIEVAL #11	11
R	1185	108 - KSC - 386C - 1057 /	2 -2	R1	SRB	GEMINI DIVE #14. CONTACT 26-2	26
R	1186	108 - KSC - 386C - 1057 /	2 -4A	R1	SRB	GEMINI DIVE 14. CONTACT 26-2	0
R	1187	108 - KSC - 386C - 1057 /	2 -12	R2	SRB	GEMINI DIVE 14. CONTACT 26-1	26
R	1188	108 - KSC - 386C - 1057 /	2 -14A	R2	SRB	GEMINI DIVE #14. CONTACT 26-1	26
R	1189	108 - KSC - 386C - 1057 /	2 -17A	R2	SRB	GEMINI DIVE #14. CONTACT 26-1	26
R	1190	108 - KSC - 386C - 1057 /	2 -20	R2	SRB	GEMINI DIVE #14. CONTACT 26-1	26
R	1191	108 - KSC - 386C - 1057 /	2 -20A	R1	SRB	GEMINI DIVE #14. CONTACT 26-2	26
R	1192	108 - KSC - 386C - 1057 /	2 -17B	R1	SRB	GEMINI DIVE #14. CONTACT 26-2	26
R	1193	108 - KSC - 386C - 1057 /	2 -15	R1	SRB	GEMINI DIVE #14. CONTACT 26-2	26

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   SRB                                          TAPE                                                            TARGET
   NUMB      PHOTO           #                  NUMBER      SYSTEM        COMMENTS                              NUMBER

R  1192   108 - KSC - 386C - 1057 /   2 -17B R1             SRB           GEMINI DIVE #14, CONTACT 26-2              26
R  1193   108 - KSC - 386C - 1057 /   2 -15  R1             SRB           GEMINI DIVE #14, CONTACT 26-2              26
R  1194   108 - KSC - 386C - 1057 /   2 -22A R2             SRB           GEMINI DIVE #14, CONTACT 26-1              26
R  1195   108 - KSC - 386C - 1057 /   2 -26A R2             SRB           GEMINI DIVE #14, CONTACT 26-2              26
R  1196   108 - KSC - 386C - 1057 /   2 -28  R2             SRB           GEMINI DIVE #14, CONTACT 26-1              26
R  1197   108 - KSC - 386C - 1057 /   2 -30  R2             SRB           GEMINI DIVE #14, CONTACT 26-1              26
R  1198   108 - KSC - 386C - 1057 /   2 -33  R2             SRB           GEMINI DIVE #14, CONTACT 26-1              26
R  1199   108 - KSC - 386C - 1057 /   2 -40A R1             SRB           GEMINI DIVE #14, CONTACT 26-2              26
R  1200   108 - KSC - 386C - 1057 /   2 -43  R1             SRB           GEMINI DIVE #14, CONTACT 26-2              26
R  1201   108 - KSC - 386C - 1115 /   2                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1202   108 - KSC - 386C - 1115 /   3                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1203   108 - KSC - 386C - 1115 /   4                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1204   108 - KSC - 386C - 1115 /   5                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1205   108 - KSC - 386C - 1115 /   6                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1206   108 - KSC - 386C - 1115 /   7                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1207   108 - KSC - 386C - 1115 /   8                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1208   108 - KSC - 386C - 1115 /   9                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1210   108 - KSC - 386C - 1115 /  11                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1211   108 - KSC - 386C - 1115 /  12                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1212   108 - KSC - 386C - 1116 /   1                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1213   108 - KSC - 386C - 1116 /   2                     SRB           OFFLOADING SRB PARTS FROM STENA             0
R  1214   108 - KSC - 386C - 1116 /   3                     SRB           OFFLOADING SRB PARTS FROM STENA WORKHORSE   0
R  1215   108 - KSC - 386C - 1116 /   4                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1216   108 - KSC - 386C - 1116 /   5                     SRB           OFFLOADING OF SRB PARTS FROM STENA WORKHORSE 0
R  1217   108 - KSC - 386C - 1116 /   6                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1219   108 - KSC - 386C - 1116 /   8                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1220   108 - KSC - 386C - 1116 /   9                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1221   108 - KSC - 386C - 1116 /  10                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1222   108 - KSC - 386C - 1116 /  11                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1223   108 - KSC - 386C - 1116 /  12                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1224   108 - KSC - 386C - 1117 /   1                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1225   108 - KSC - 386C - 1117 /   2                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1226   108 - KSC - 386C - 1117 /   3                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1227   108 - KSC - 386C - 1117 /   4                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1228   108 - KSC - 386C - 1117 /   5                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1229   108 - KSC - 386C - 1117 /   6                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1230   108 - KSC - 386C - 1117 /   7                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1231   108 - KSC - 386C - 1117 /   8                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1232   108 - KSC - 386C - 1117 /   9                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1233   108 - KSC - 386C - 1117 /  10                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1234   108 - KSC - 386C - 1117 /  11                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1235   108 - KSC - 386C - 1117 /  12                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1236   108 - KSC - 386C - 1118 /   1                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1237   108 - KSC - 386C - 1118 /   2                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1238   108 - KSC - 386C - 1118 /   3                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1239   108 - KSC - 386C - 1118 /   4                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1240   108 - KSC - 386C - 1118 /   5                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
R  1241   108 - KSC - 386C - 1118 /   6                     SRB           OFFLOADING OF SRB PARTS FROM STENA          0
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     SRR                                  TAPE                                                  TARGET
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R  1242   108 - KSC - 386C - 1118 /   7             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
R  1243   108 - KSC - 386C - 1118 /   8             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
R  1244   108 - KSC - 386C - 1118 /   9             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
R  1245   108 - KSC - 386C - 1118 /  10             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
R  1246   108 - KSC - 386C - 1118 /  11             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
R  1247   108 - KSC - 386C - 1118 /  12             SRB        OFFLOADING OF SRB PARTS FROM STENA     0
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APPENDIX D
List of Search Video Tapes

As part of the Search, Recovery and Reconstruction Team effort, a library of Underwater Search Video Tapes was maintained. Search videos were copied and provided to JSC, MSFC, and the Supervisor of Salvage, USN. The master video tape was kept in the data viewing area, Room 2174, Headquarters Building, KSC.

Video tapes were given an SRR Team number and local experts provided a characterization of the video and attempted to identify the source of the debris, i.e. SRB, Orbiter, TDRSS, ET and IUS.

These data were entered into a personal computer data base system. This Appendix D is a list of all Underwater Search Video Tapes logged into the data base as of close of business, May 5, 1986.

Search video tapes were taken during the debris search and characterization phase. Often these video tapes were taken by vessels with little or no recovery capability. Views are of pieces of debris, although ocean conditions often produced poor or unusable images.

UNDERWATER VIDEO LOG

** TAPE NUMBER : 001

* SOURCE OF TAPE : IUS (1st Scorpio Tape)

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
12:52	KEVLAR PIECES	IUS	0	02/02/86	D. DUBBS, 6555 ASTG/USAF
12:52:51	Y-DAMPER WITH SPRING BEAM ATTACHMENT H/W & PROPELL. PIECES	IUS	0	02/02/86	D DUBBS, 6555 ASTG/USAF
13:03:59	AFT ASE Y-DAMPER	IUS	0	02/02/86	L. KENT IRVIN, BOEING
13:06	PROPELLANT PIECES (LARGE)	IUS	0	02/02/86	D DUBBS, 6555 ASTG/USAF
13:09:38	PROPELLANT PIECES	IUS	0	02/02/86	D DUBBS, 6555 ASTG/USAF
13:11:36	PORT SLIP RING WITH PIN PULLER & LARGE PIECE OF PROPELLANT	IUS	0	02/02/86	D DUBBS, 6555 ASTG/USAF
13:15:45	AFT ASE SLIP RING	IUS	0	02/02/86	L. KENT IRWIN, BOEING
13:17:22	LRG PIECE OF PROPELLANT FROM AFT DOME	IUS	0	02/02/86	D DUBBS, 6555 ASTG/USAF
13:18:25	AFT ASE FRAME-END TORN OUT	IUS	0	02/02/86	D DUBBS, 6555 ASTG
13:19:50	SEPARATION SPRING	IUS	0	02/02/86	L. KENT IRWIN, BOEING
13:21	PROPELLANT BY ASE	IUS	0	02/02/86	D DUBBS, 6555 ASTG
13:22	AFT ASE STRUCTURE	IUS	0	02/02/86	L. KENT IRWIN, BOEING
13:26	PROPELLANT LAYING ON ASE	IUS	0	02/02/86	D DUBBS, 6555 ASTG
13:34	BATTERY	IUS	0	02/02/86	D DUBBS, 6555 ASTG
13:34:39	BATTERY FROM AFT ASE	IUS	0	02/02/86	L. KENT IRWIN, BOEING
13:35	SPRING BEAM SPHERICAL BEARING	IUS	0	02/02/86	D DUBBS, 6555 ASTG

** TAPE NUMBER : 002A

* SOURCE OF TAPE : 2nd Scorpio Tape, Angle A

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
16:07	AFT ASC FRAME FOR IUS	IUS	0	02/02/86	MUNAFO,P.M EH22/MSFC
16:08	AFT ASE FRAME	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:09:00	POSSIBLE 'BELLY' SIDE OF AFT IUS ASE	IUS	0	02/02/86	WALZEL,B.K. BOEING/IUS
16:13	TOP DECKING OF AFT ASE FRAME	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:15	SUPER ZIP	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:17	SPRING BEAM PIVOT SHAFT BUSHING AND PROPELLANT	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:32	BATTERY	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:32:40	POSSIBLE BATTERY	IUS	0	02/02/86	WALZEL,B.K. BOEING/IUS
16:35	BATTERY	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:35:40	POSSIBLE BATTERY	IUS	0	02/02/86	WALZEL,B.K. BOEING/IUS
16:37	BATTERY AND RETAINER BEARING	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:38	Y-DAMPER	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:39	TOP DECKING OF AFT ASE	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:46	BATTERY ATTACH POINTS ON AFT ASE	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:48:00	OUTBOARD AFT ASE STRU.(TOWARD PLB DOORS)	IUS	0	02/02/86	WALZEL,B.K. BOEING/IUS
16:51	SPRING BEAM AND TRUNNION	IUS	0	02/02/86	S KOLB, 6555 ASTG
16:51:48	PROPELLANT	IUS	0	02/02/86	S KOLB, 6555 ASTG
17:34:30	Y-DAMPER FROM IUS	IUS	0	02/02/86	MOLONEY, DICK /BOEING

** TAPE NUMBER : 002B

* SOURCE OF TAPE : 2nd Scorpio Tape, Angle B

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
020	AFT ASE	IUS	0	02/02/86	J PARKER, 6555 ASTG
520	POSSIBLE BATTERY	IUS	0	02/02/86	WALZEL, B.K. /BOEING
520	BATTERY	IUS	0	02/02/86	J PARKER
556	'BLACK BOX'		0	02/02/86	PARKER, M.J. /ROCKWELL
560	IUS INTERSTAGE PORTION	IUS	0	02/02/86	MAZUR, P. 6555 ASTG/USAF
570	IUS Y-DAMPER PIECE	IUS	0	02/02/86	MAZUR, P. 6555 ASTG/USAF

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POSITION     DESCRIPTION                                                 SYSTEM      TARGET    DATE      COMMENTS
                                                                                     NUMBER    TAPE        BY
                                                                                             RECEIVED

590          POSSIBLE BATTERY                                            IUS              0 02/02/96 WALZEL, B.K.   /BOEING
590-630      IUS AFT-ASE SUPER ZIP RING PORTION                          IUS              0 02/02/86 MAZUR, P. 6555 ASTG/USAF
607          WHITE STRUCTURE                                                              0 02/02/86 PARKER, M.J.   /ROCKWELL
650          WHITE STRUCTURE                                                              0 02/02/86 PARKER, M.J.   /ROCKWELL
700          GOOD SIZE SECTION OF WHITE STRUCTURE                                         0 02/02/86 PARKER, M.J.   /ROCKWELL
850-875      'BLACK BOX'                                                                  0 02/02/86 PARKER, M.J.   /ROCKWELL
855          POSIBLE BATTERY                                             IUS              0 02/02/86 WALZEL, B.K.    /BOEING
870          BATTERY                                                     IUS              0 02/02/86 J PARKER, 6555 ASTG
880          IUS SPREADER BEAM AFT ASE                                   IUS              0 02/02/86 WALZEL, B.K.    /BOEING
880          TRUNNION AND END OF SPREADER BEAM                           IUS              0 02/02/86 J PARKER
884          TRUNION                                                                      0 02/02/86 PARKER, M.J.   /ROCKWELL
925          BLACK BOX,3X8in,HARNESS ATTACHED                                             0 02/02/86 PARKER, M.J.   /ROCKWELL
995          POSSIBLE PART OF SUPER-ZIP RING                             IUS              0 02/02/86 WALZEL, B.K.    /BOEING
NO POS.      IUS ASE SPREADER BEAM WITH TRUNION                          IUS              0 02/02/86 MUNAFO, P.M.  EH22/MSFC

** TAPE NUMBER    : 003A

* SOURCE OF TAPE : 3rd Scorpio Tape, Angle A
17:51        BATTERY                                                     IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
17:51:45     BATTERY-IUS                                                 IUS              0 02/02/86 WALZEL,B.K. BOEING/IUS
17:53        RETAINER SLIP RING AND BATTERY                              IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
17:54        SPREADER BEAM AND TRUNION                                   IUS              0 02/02/86 MUNAFO,P.M.  EH22/MSFC
17:54        TRUNNION AND SPREADER BEAM                                  IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
17:54:40     AFT IUS ASE LOWER TRUNION                                   IUS              0 02/02/86 WALZEL,B.K. BOEING/IUS
18:01:15     SUPER ZIP RING                                              IUS              0 02/02/86 WALZEL,B.K. BOEING/IUS
18:06        KEVLAR FIBERS AND COMPLETE BEAM (L.H.)                      IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:06:00     IUS AFT ASE TRUNION                                         IUS              0 02/02/86 WALZEL, B.K. BOEING/IUS
18:13        AFT ASE FRAME SEGMENT                                       IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:15        SIDE WALL ASE AND PART OF SUPER-ZIP                         IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:18        LARGE SKIN AND STRINGER ASSEMBLY                            IUS              0 02/02/86 MUNAFO,P.M. EH22/MSFC
18:20        LARGE PIECE OF MLI                                          IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:22        Y-DAMPER AND BRACKET                                        IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:23        CENTERING SPRING                                            IUS              0 02/03/86 J PARKER
18:26        AFT ASE - PART NUMBER AND WIRE BUNDLES                      IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:35        KEVLAR STRANDS                                              IUS              0 02/03/86 J PARKER
18:37        AFT ASE ACCESS HOLE                                         IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:40        TRUNNION AND SPREADER BEAM                                  IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:42         AFTA ATTACH BRACKET                                        IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:43        BATTERY                                                     IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:44        SLIP RING PARTS                                             IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:45        PROTRACTER                                                  IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:46         UPPER SURFACE AFT ASE                                      IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:48        BOTTOM ASE RING WITH INSTRUMENTATION (DASIS PRES .XDUCER)   IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:50        BATTERY                                                     IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:51        Y-DAMPER                                                    IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
18:53         KEVLAR FIBERS                                              IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
19:16        PROPELLANT                                                  IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
19:17        Y-DAMPER WITH BRACKET                                       IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
19:30        Y-DAMPER                                                    IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
19:36        Y-DAMPER (DIFFERENT FROM 19:30)                             IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
19:37        SPRING BEAM BEARING AND PROPELLANT                          IUS              0 02/03/86 J PARKER, 6555 ASTG/USAF
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POSITION    DESCRIPTION                                                SYSTEM      TARGET   DATE      COMMENTS
                                                                                   NUMBER   TAPE         BY
                                                                                            RECEIVED

19:39:20    CENTERING SPRING                                          IUS               0 02/02/86 MOLONEY. DICK  BOEING/IUS
19:40       SECTION OF AFT ASE WALL                                   IUS               0 02/03/86 J PARKER. 6555 ASTG/USAF
19:40:55    POSSIBLE ASE                                              IUS               0 02/02/86 MOLONEY. DICK BOEING/IUS
19:42       COUPLING FOR SUPER-ZIP AND CONTAINMENT TUBE               IUS               0 02/03/86 J PARKER. 6555 ASTG/USAF
19:46       AFTA SHAFT                                                IUS               0 02/03/86 J PARKER. 6555 ASTG/USAF

** TAPE NUMBER   : 003B

* SOURCE OF TAPE : 3rd Scorpio Tape. Angle B
030         POSSIBLE SIP PANEL                                                          [illegible] SHELL/RAMSEY USAF/6555 TH
345         IUS BATTERY                                               IUS               0 02/02/86 WALZEL.B.K.  BOEING/IUS
345         IUS BATTERY                                               IUS               0 02/02/86 SHELL/RAMSEY USAF/6555 TH
347         BATTERY AND ASE STRUCTURE                                 IUS               0 02/03/86 T HILL. AEROSPACE
389         PROPELLANT AND BATTERY                                    IUS               0 02/03/86 T HILL. AEROSPACE
700         IUS AFT ASE TILT INDICATOR                                IUS               0 02/02/86 WALZEL.B.K. BOEING/IUS
820         KEVLAR                                                    IUS               0 02/03/86 T HILL. AEROSPACE
842         SRM WITH WINDING UNRAVELING FROM CASE                     IUS               0 02/02/86 MAZUR. P. 6555 ASTG/USAF
850         FOIL. KEVLAR FIBERS ON IUS SRM CASING                     IUS               0 02/02/86 SHELL/RAMSEY USAF/6555 TH
873         'NO STEP' STENCIL ON AFT DOME OF SRM-1. CABLES AND CLAMPS IUS               0 02/03/86 T HILL. AEROSPACE

** TAPE NUMBER   : 004A

* SOURCE OF TAPE : Scorpio. Sonat Debris Search. Angle A
04:43:00    CABLING                                                   IUS               0 02/02/86 MOLONEY.DICK BOEING/IUS
04:45       KEVLAR                                                    IUS               0 02/03/86 W BEST. BAO
04:50:48    BATTERY OF IUS                                            IUS               0 02/02/86 MOLONEY.DICK BOEING/IUS
04:51       BATTERY                                                   IUS               0 02/03/86 W BEST. BAO
04:53       PROPELLANT AND BATTERY                                    IUS               0 02/03/86 W BEST. BAO
04:55:30    BATTERY OF IUS                                            IUS               0 02/02/86 MOLONEY.DICK BOEING/IUS
05:04:00    BATTERY FOR IUS                                           IUS               0 02/02/86 WALZEL.B.K.  BOEING/IUS
05:14       PROTRACTER                                                IUS               0 02/03/86 W BEST. BAO
05:14:50    AFT ASE TILT INDICATOR                                    IUS               0 02/02/86 WALZEL.B.K.  BOEING/IUS
05:29       SRM-1 KEVLAR AND CABLES                                   IUS               0 02/03/86 W BEST. BAO
05:30:00    POSSIBLE SRM ACTUATOR/MOTOR CASE                          IUS               0 02/02/86 WALZEL.B.K.  BOEING/IUS
21:46:49    TRUNION                                                   IUS               0 02/02/86 MOLONEY. DICK  BOEING
21:47       SPRING BEAM WITH TRUNNION                                 IUS               0 02/03/86 W BEST. BAO
22:35       KEVLAR                                                    IUS               0 02/03/86 W BEST. BAO

** TAPE NUMBER   : 004B

* SOURCE OF TAPE : Scorpio. Sonat Debris Search. Angle B
237         AFT ASE                                                   IUS               0 02/03/86 R TONNER. AEROSPACE
366         SIP PANEL                                                 IUS               0 02/03/86 R TONNER. AEROSPACE
380         POSSIBLE SIP PANEL                                        ORB STRUC         0 02/02/86 KILGORE.JOE H. ROCKWELL
412         SLIP RING IUS                                             IUS               0 02/03/86 R TONNER. AEROSPACE
451         AFTA                                                      IUS               0 02/03/86 R TONNER. AEROSPACE
470         Y-DAMPER                                                  IUS               0 02/03/86 R TONNER. AEROSPACE
480         ASE AFT FRAME TILT ACTUATOR                               IUS               0 02/02/86 WALZEL.B.K. BOEING/IUS
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POSITION     DESCRIPTION                                                        SYSTEM      TARGET   DATE      COMMENTS
                                                                                            NUMBER   TAPE         BY
                                                                                                     RECEIVED

** TAPE NUMBER    : 005A

* SOURCE OF TAPE : Scorpio #50, Angle A
2452         POSSIBLE SIP PANEL                                                 ORB STRUC          0 02/03/86 KILGORE,JOE H. ROCKWELL
2750         FWD ASE CENTERING SPRING                                           IUS                0 02/03/86 WALZEL,B.K. BOEING/IUS
5375         Y-DAMPER RETRIEVAL                                                 IUS                0 02/03/86 MOLONEY,DICK BOEING/IUS

** TAPE NUMBER    : 005B

* SOURCE OF TAPE : Scorpio #50, Angle B
090          TANK-PROPELLANT OXIDIZER OMS                                       OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
390          TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
549          TANK- SECOND OXIDIZER                                              OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
716          TANK- SECOND OXIDIZER                                              OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
870          TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL

** TAPE NUMBER    : 006A

* SOURCE OF TAPE : Scorpio #50, Metal Tanks, Angle A
22:45:50     TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
22:55:81     TANK- SECOND OXIDIZER                                              OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
23:08:48     TANK- SECOND OXIDIZER                                              OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
23:21:18     TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
23:37:30     TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
23:49:00     TANK (GLIMPSE)                                                     OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL

** TAPE NUMBER    : 006B

* SOURCE OF TAPE : Scorpio #50, Metal Tanks, Angle B
038          TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL
307          TANK- PROPELLANT OXIDIZER OMS                                      OMS                0 02/03/86 KILGORE,JOE H. ROCKWELL

** TAPE NUMBER    : 008

* SOURCE OF TAPE : 2-15-86:P+T BFR & 2-16-86:SRB Segment, Deep Drone #1
665-END      LH AFT SECTION WITH ETA RING                                       SRB                  02/16/86 BOB HILLARD
ALL          NO ORBITER HARDWARE IDENTIFIED                                                          02/16/86 JOE KILGORE, RI LSS

** TAPE NUMBER    : 009

* SOURCE OF TAPE : 2-15-86:P+T BFR & 2-16-86:SRB Segment, Deep Drone #2
ALL          NO ORBITER HARDWARE IDENTIFIED                                                          02/16/86 JOE KILGORE, RI LSS

** TAPE NUMBER    : 010

* SOURCE OF TAPE : Fixed Camera with Deep Drone #1
868-890      LOOKS LIKE A SEGMENT, VISIBILITY VERY POOR                         SRB                  02/15/86 BOB HILLARD
ALL          NO ORBITER HARDWARE IDENTIFIED                                                          02/15/86 JOE KILGORE, RI LSS
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                                                         UNDERWATER VIDEO LOG

POSITION   DESCRIPTION                                                    SYSTEM     TARGET    DATE      COMMENTS
                                                                                     NUMBER    TAPE        BY
                                                                                             RECEIVED


** TAPE NUMBER   : 011

* SOURCE OF TAPE : Fixed Camera with Deep Drone #2
ALL        COMPLETELY OUT OF FOCUS                                        SRB                 02/15/86 BOB HILLARD
ALL        NO ORBITER HARDWARE IDENTIFIED                                                     02/15/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 012

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 1
188        HYD. RES., PART OF TVC FRAME AT PT. A                                            0 02/15/86 MC COOL, MSFC EP01
212        BSM                                                                              0 02/15/86 MC COOL, MSFC EP01
224        PIECE OF AFT SKIRT AROUND TVC SYSTEM                                             0 02/15/86 MC COOL, MSFC EP01
266        INSIDE AFT SKIRT,PART OF KICK RING                             SRB               0 02/15/86 MC COOL, MSFC EP01
282        NOZZLE, BLAST SHIELD FOR LSC (UPSIDE DN)                       SRB               0 02/15/86 MC COOL, MSFC EP01
324        BSM, ANOTHER VIEW                                              SRB               0 02/15/86 MC COOL, MSFC EP01
380        AFT STRU. END OF AFT SKRT INT.COSTAL RIB                       SRB               0 02/15/86 MC COOL, MSFC EP01
430        FWD NOZZLE EXIT CONE STRU. HOUSING                             SRB               0 02/15/86 MC COOL, MSFC EP01
ALL        NO IDENTIFIABLE FRAGMENTS OR ASSYS OF TDRSS                    -                   02/15/86 JOHN PIACENTINI, TRW
ALL        NO ORBITER HARDWARE IDENTIFIED                                                     02/15/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 013

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 2
123        AFT SKIRT STRU. EXT. VIEW LOOKING INWARDS TO TVC               SRB               0 02/15/86 MC COOL, MSFC  EP01
142        STRUCTURE ? (BRKT)                                             SRB               0 02/15/86 MC COOL, MSFC EP01
171        STRUCTURE ?                                                    SRB               0 02/15/86 MC COOL, MSFC EP01
198        TVC SYST BKT                                                   SRB               0 02/15/86 MC COOL, MSFC EP01
214        TVC MANIFOLD                                                   SRB               0 02/15/86 MC COOL, MSFC EP01
228        AFT SKRT,T-RING,FASTENERS,GUSSETS,CLIPS.POS. FUEL ISO VALVE    SRB               0 02/15/86 MC COOL, MSFC EP01
314        BOTTOM OF AFT SKIRT                                            SRB               0 02/15/86 MC COOL, MSFC EP01
450-470    POSSIBLE AFT DOME, SEE GLASS WRAP                              SRB               0 02/15/86 MC COOL, MSFC EP01
ALL        NO IDENTIFIABLE FRAGMENTS OR ASSYS OF TDRSS                    -                   02/15/86 JOHN PIACENTINI, TRW
ALL        NO ORBITER HARDWARE IDENTIFIED                                                     02/15/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 014

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 3
034-038    STRUTURAL MEMBER,NOZZLE FIXED HOUSING, GUIDE PIN, BOLT HOLES SRB                 0 02/15/86 MC COOL, MSFC EP01
118        FUEL ISO VALVE ATTACH STRUCTURE                                SRB               0 02/15/86 MC COOL, MSFC EP01
186        CYLINDER SECTION OF SRM                                        SRB               0 02/15/86 MC COOL, MSFC EP01
271        SMALL DEBRIS                                                                     0 02/15/86 MC COOL, MSFC EP01
282        SECTION OF KICK RING                                           SRB               0 02/15/86 MC COOL, MSFC EP01
365        AFT SKIRT WITH BSM                                             SRB               0 02/15/86 MC COOL, MSFC EP01
434        AFT SKIRT STRUCTURE - AFT ATTACH BSM                           SRB               0 02/15/86 MC COOL, MSFC EP01
ALL        NO IDENTIFIABLE FRAGMENTS OR ASSYS OF TDRSS                    -                   02/15/86 J. TIACENTINI, TRW
ALL        NO ORBITER HARDWARE IDENTIFIED                                                     02/15/86 JOE KILGORE, RI LSS
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UNDERWATER VIDEO LOG

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 015					
* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 4					
018	ACTUATOR ATTACH BRACKET - AFT SKIRT	SRB	0	02/15/86	MC COOL, MSFC EP01
060	TUNNEL FLOOR PLATE AND ROOSTER TAIL	SRB	0	02/15/86	MC COOL ,MSFC EP01
087-090	PHENOLIC	SRB	0	02/15/86	MC COOL, MSFC EP01
102	ALUMINIM SKIN - AFT SKIRT	SRB	0	02/15/86	MC COOL, MSFC EP01
123	UNIDENTIFIED - SHEETMETAL ?		0	02/15/86	MC COOL, MSFC EP01
142	AFT SEGMENT STIFFENER "T" RING	SRB	0	02/15/86	MC COOL, MSFC EP01
155	UNIDENTIFIED SHEETMETAL		0	02/15/86	MC COOL,MSFC EP01
177	PIN RETAINER BAND	SRB	0	02/15/86	MC COOL,MSFC EP01
190-196	MAY BE PART OF S/C CYLINDER WED (UPPER)	TDRSS		02/15/86	J. TIACENTINI, TRW
199 & 218	NOZZLE GLASS PHENOLIC	SRB	0	02/15/86	MC COOL, MSFC EP01
240	STIFFENER RING	SRB	0	02/15/86	MC COOL, MSFC EP01
244	NOZZLE GLASS PHENOLIC	SRB	0	02/15/86	MC COOL,MSFC EP01
256	AFT STRUCTURE STIFFENER	SRB	0	02/15/86	MC COOL,MSFC EP01
263	GLASS PHENOLIC KING & UNIDENTIFIED AL. STRUCTURE BRACKET	SRB	0	02/15/86	MC COOL,MSFC EP01
271	NOZZLE GLASS PHENOLIC	SRB	0	02/15/86	MC COOL,MSFC EP01
290	SHORT SECTION TUNNEL COVER	SRB	0	02/15/86	MC COOL,MSFC EP01
311	NOZZLE THROAT CARBON PHENOLIC KING	SRB	0	02/15/86	MC COOL,MSFC EP01
325	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL,MSFC EP01
352	PHENOLIC GLASS AND CARBON RING AREA	SRB	0	02/15/86	MC COOL,MSFC EP01
374	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL,MSFC EP01
398	CARBON PHENOLIC RING AND RECTANGULAR PLATE ?	SRB	0	02/15/86	MC COOL,MSFC EP01
412	ALUMINUM SHEET FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
417	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL, MSFC EP01
431	AFT INTERNAL RING FRAGMENT ?	SRB	0	02/15/86	MC COOL, MSFC EP01
445-452	CENTRAL CYLINDER TANK SUPPORT	TDRSS		02/15/86	J. TIACENTINI
455	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL, MSFC EP01
ALL	NO TDRSS ID			02/15/86	CHESTER HAMER
ALL	NO ORBITER HARDWARE IDENTIFIED			02/15/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 016					
* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 5					
030	AFT SECTION WITH INSTAFOAM (SMALL)	SRB	0	02/15/86	MC COOL, MSFC EP01
070-090	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL, MSFC EP01
125	KICK RING PHENOLIC COVER	SRB	0	02/15/86	MC COOL, MSFC EP01
181	CARBON PHENOLIC NOZZLE	SRB	0	02/15/86	MC COOL, MSFC EP01
189	LINEAR SHAPE CHARGE (NOZZLE SEVERANCE)	SRB	0	02/15/86	MC COOL, MSFC EP01
201-202	PHENOLIC GLASS	SRB	0	02/15/86	MC COOL, MSFC EP01
ALL	NO IDENTIFIABLE FRAGMENTS OR ASSYS OF TDRSS	-		02/15/86	J. TIACENTINI, TRW
ALL	NO ORBITER HARDWARE IDENTIFIED			02/15/86	JOE KILCORE, RI LSS
** TAPE NUMBER : 017					
* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1245, TAPE 1					
061-410	ALL VIEWS OF SEGMENT ARE EXTERIOR	SRB	0	02/15/86	MC COOL, MSFC EP01
294	PIN RETAINER BAND	SRB	0	02/15/86	MC COOL, MSFC EP01
300	KICK RING	SRB	0	02/15/86	MC COOL, MSFC EP01
366	AFT SKRT & SEGMENT(KICK RING,AFT CLOSURE,AFT STIFFENER SEG)	SRB	0	02/15/86	MC COOL, MSFC EP01

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423	FWD EXIT CONE HOUSING,EXT VERY SOOTED,STRU DAMAGE TO JOINT	SRB	0	02/15/86	MC COOL, MSFC EP01
ALL	NO ORBITER HARDWARE IDENTIFIED			02/15/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 018					
* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1245, TAPE 2					
022	AFT SKIRT FRAGMENTS	SRB	0	02/15/86	MC COOL, MSFC EP01
026	SMALL AFT SKIRT FRAGMENTS	SRB	0	02/15/86	MC COOL, MSFC EP01
089	TVC APU SYSTEM WITH HYDRAULIC PUMP	SRB	0	02/15/86	MC COOL, MSFC EP01
119-180	SUB OPERATOR DESCRIBED OBJECT AS PART OF EXIT CONE	SRB	0	02/15/86	MC COOL, MSFC EP01
251	AFT SKIRT RING AND SKIN FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
346	GLASS PHENOLIC	SRB	0	02/15/86	MC COOL, MSFC EP01
359	SECTION OF AFT SKIRT	SRB	0	02/15/86	MC COOL, MSFC EP01
365	AFT SKIRT AFT RING FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
374	POSSIBLE NOZZLE SNUBBER	SRB	0	02/15/86	MC COOL, MSFC EP01
414	FWD EXIT CONE HOUSING	SRB	0	02/15/86	MC COOL, MSFC EP01
448	AFT SKIRT SEGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
458	PART OF UPPER TVC FRAME AND HYDRAULIC RESERVOIR	SRB	0	02/15/86	MC COOL, MSFC EP01
ALL	NO ORBITER HARDWARE IDENTIFIED			02/15/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 019					
* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1246, TAPE 1					
016	SMALL UNIDENTIFIED FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
044	ELECTRICAL CABLE	SRB	0	02/15/86	MC COOL, MSFC EP01
062	INTERNAL PLATES OF HDP	SRB	0	02/15/86	MC COOL, MSFC EP01
082	AFT SKRT STRUC.,SECTION OF MID-RING FOAM & SKIN PNL,4x4 ft	SRB	0	02/15/86	MC COOL, MSFC EP01
143 & 156	AFT SKIRT FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
164	FEED THRU ASSEMBLIES (ROOSTER TAIL & TUNNEL FLOOR)	SRB	0	02/15/86	MC COOL, MSFC EP01
182	AFT SKIRT FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
190	ALUMINUM FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
208	CASE SEGMENT STIFFENER RING WITH SPLICE JOINT	SRB	0	02/15/86	MC COOL, MSFC EP01
217	LOWER TVC FRAME SECTION & HYDRAULIC RESERVOIR CLAMP	SRB	0	02/15/86	MC COOL, MSFC EP01
236-284	CASE SEGMENT SHOWING TANG WITH TANG SLOT	SRB	0	02/15/86	MC COOL, MSFC EP01
316-338	AFT SKRT STRUC. TRAILING EDGE (3x12 ft) & WHALEBONE	SRB	0	02/15/86	MC COOL, MSFC EP01
394	AFT SKIRT FRAGMENT	SRB	0	02/15/86	MC COOL, MSFC EP01
409	AFT SKIRT FRAGMENT WITH CORK AND RING SHIMS	SRB	0	02/15/86	MC COOL, MSFC EP01
439	NOZZLE CARBON PHENOLIC - INTACT	SRB	0	02/15/86	MC COOL, MSFC EP01
456	UNIDENTIFIED NOZZLE RING WITH FLAP	SRB	0	02/15/86	MC COOL, MSFC EP01
478	CLEVIS RING JOINT - POSSIBLE O-RING GROOVE	SRB	0	02/15/86	MC COOL, MSFC EP01
ALL	NO ORBITER HARDWARE IDENTIFIED			02/15/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 020					
* SOURCE OF TAPE : DEEP DRONE FIXED PART 1					
170	MLI AND WHAT LOOKS LIKE TDRS SEPARATION BAND ASSY 127971 WHITE DEBRIS NOT TDRS - POSSIBLY IUS	TDRSS		02/09/86	CHESTER HAMER, TRW
248	TDRS TO IUS ADAPTER SEPARATION BAND (NOT WITH OTHER DEBRIS RECOVERED FROM SAME AREA)"NOT RECOVERED??"	TDRS		02/09/86	CHESTER HAMER, TRW
248	TDRS TO IUS ADAPTER SEPARATION BAND. (NOT WITH OTHER DEBRIS RECOVERED FROM SAME AREA)	TDRS		02/09/86	-

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248          TDRS TO IUS ADAPTER SEPARATION BAND  (NOT WITH OTHER DEBRIS  TDRSS               02/09/86 CHESTER HAMER, TRW
             RECOVERED FROM SAME AREA (NOT RECOVERED??)
250          MORE TDRS STRUCTURE                                           TDRS                02/09/86 -
250          MORE TDRS STRUCTURE, CAN'T SPECIFICALLY ID DUE TO POOR       TDRSS               02/09/86 CHESTER HAMER, TRW
             PICTURE QUALITY
450          128879 WEB S/C MODULE CYLINDER                                TDRSS               02/09/86 CHESTER HAMER, TRW
496          CONNECTOR BRT LANYARD, S/C 128058 WITH MLI                    TDRS                02/09/86 CHESTER HAMER
563          RING SEPARATION S/C 127539 - WITH WEB & PARTIAL 127507        TDRS                02/09/86 CHESTER HAMER
             SUPPORT STRUT
580          LOWER S/C MODULE CYLINDER WEB WITH 1 3/4 STRUTS ATTACHED      TDRSS               02/09/86 CHESTER HAMER, TRW
             (RECOVERED)
750          TDRS HARNESS ATTACHED TO SHEET METAL DEBRIS OF WEB            TDRS                02/09/86 CHESTER HAMER
956          IUS ADAPTER (PARTIAL)                                         TDRS                02/09/86 CHESTER HAMER

* SOURCE OF  TAPE : DEEP DRONE FIXED TAPE 1
ALL          MOSTLY TDRS DEBRIS                                            TDRS                02/09/86 KENNETH CERESKA, BAC

* SOURCE OF  TAPE : DEEP DRONE FIXED PART 1
ALL          NO ORBITER HARDWARE IDENTIFIED                                                    02/09/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 021

* SOURCE OF  TAPE : DEEP DRONE FIXED PART 2
ALL          NO ORBITER HARDWARE IDENTIFIED                                                    02/09/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 022

* SOURCE OF  TAPE : DEEP DRONE PAN & TILT PART 1
10           IUS ADAPTER, 126900-ASSY, 127556-1-LONGERON, 127955-2-WEB,    TDRSS               02/09/86 CHESTER HAMER
             127593-STIFFENER & SUN SHIELD BRACKETS
200          "CANNOT MAKE IDENTIFICATION" THE DEBRI (BAND, STRAPPING) PN                       02/09/86 BOB HILLARD
             #11932 ASSY 127973-3?? ORBITER OR IUS
258          MLI                                                           TDRSS               02/09/86 CHESTER HAMER, TRW
283          SEPARATION BAND SEEN IN COUNTER REFERENCE 92.  APPEARS TO BE  TDRSS               02/09/86 CHESTER HAMER, TRW
             SOMETHING WRAPPED IN MLI. CAN BE SEEN IN BACKGROUND (NOT
             RECOVERED)
29           REMAINS OF TDRS TO IUS ADAPTER (RECOVERED)                    TDRSS               02/09/86 CHESTER HAMER, TRW
34           25755c-1, LONGER ON IUS ADAPTR 126900 ASSY, 127957-3          TDRSS               02/09/86 CHESTER HAMER, TRW
             STIFFENER, 127955-1 WEB
380          IUS ADAPTER ASSY, 126900, STIFFENER & LONGERON                TDRSS               02/09/86 CHESTER HAMER
400          INTEGRATED CIRCUIT BOARD, ORBITER OR IUS                                          02/09/86 BOB HILLARD
460          CYLINDRICAL OBJECT, ORBITER OR IUS                                                02/09/86 BOB HILLARD
463          CYLINDER ASSY S/C MODULE, 127527-MLI                          TDRSS               02/09/86 CHESTER HAMER, TRW
489          SEP BRACKET #128057 & HARNESS CONNECTORS, 127879 ASSY-P-138   TDRSS               02/09/86 CHESTER HAMER, TRW
             & 139
529          MLI, IUS ADAPTER                                              TDRSS               02/09/86 CHESTER HAMER
542          POSSIBLY ORBITER?                                                                 02/09/86 BOB HILLARD
550          127507 SUPPORT STRUT & 127539 RING & 127879 S/C MODULE CYL    TDRSS               02/09/86 CHESTER HAMER
596          PN #127527-1??                                                SRB                 02/09/86 BOB HILLARD
599          POSSIBLE 127530 CYLINDER ASSY TANK MODULE & MLI               TDRSS               02/09/86 CHESTER HAMER
600-639      S/C PORTION OF SEPARATION RING ATTACHED TO LOWER S/C MODULE   TDRSS               02/09/86 CHESTER HAMER, TRW
             CYLINDER WEB (RECOVERED)
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670	127507 SUPPORT STRUT & 127539 RING & 127879 S/C MODULE CYL	TDRSS		02/09/86	CHESTER HAMER
691	SEPARATION BAND WITH LOWER S/C MODULE CYLINDER WEB IN BACKGROUND (BAND NOT RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
760	TDRS TO IUS ADAPTER HARNESS (RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
766	ORD SEP HARNESS P-139-138	TDRSS		02/09/86	CHESTER HAMER
766	IUS ADAPTER	TDRSS		02/09/86	CHESTER HAMER
773 & 826	CABLE ASSY OUT OF FOCUS ON P/N #, ORBITER OR IUS			02/09/86	BOB HILLARD
860	127556-1 LONGERON FOOT ON IUS	TDRSS		02/09/86	CHESTER HAMER
91	SEPARATION BAND, 127971	TDRSS		02/09/86	CHESTER HAMER, TRW
92	TDRS TO IUS SEPARATION BAND (NOT RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
962	IUS ADAPTER 126900, WEB, STIFFENER 7 LONGERON SUN SHIELD SUPPORT BRACKETS	TDRSS		02/09/86	CHESTER HAMER
ALL	NO ORBITER HARDWARE IDENTIFIED			02/09/86	JOE KILGORE, RI LSS
ALL	NO ET IDENTIFIED			02/09/86	W. FEAGAN, MMC
** TAPE NUMBER : 023					
* SOURCE OF TAPE : DEEP DRONE PAN & TILT PART 2					
0-160	THIN SKINNED STRUCTURE WITH RIBS	SRB		02/09/86	BOB HILLARD
0-744	TDRS TO IUS ADAPTER/DEBRIS (RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
11	IUS ADAPTER TDRS - PARTIAL SRUCTURE, WEB STIFFENER, LONGERON	TDRS		02/09/86	CHESTER HAMER
132	IUS ADAPTER PARTIAL STRUCTURE	TDRS		02/09/86	CHESTER HAMER
386	IUS ADAPTER PARTIAL STRUCTURE TDRS	TDRS		02/09/86	CHESTER HAMER
581	TDRS DEBRIS (SHEET METAL) & MLI	TDRS		02/09/86	CHESTER HAMER
646	TDRS DEBRIS (SHEET METAL)	TDRS		02/09/86	CHESTER HAMER
812	UNABLE TO ID AS TDRS - COULD BE IUS	TDRS		02/09/86	CHESTER HAMER
** TAPE NUMBER : 024					
* SOURCE OF TAPE : DEEP DRONE FIXED TAPE 2					
0-515	LOWER S/C CYLINDER WEB RECOVERY EFFORT	TDRSS		02/09/86	JOHN PIACENTINI, TRW
515-636	PORTION OF TDRSS TO IUS ADAPTER SEPARATION RING WITH ONE OF FOUR KICKOFF SPRINGS ATTACHED (SAME AS TAPE 29??) (RECOVERED LESS SPRING	TDRSS		02/09/86	JOHN PIACENTINI, TRW
650-END	IUS	IUS		02/09/86	JOHN PIACENTINI, TRW
ALL	NO ORBITER HARDWARE IDENTIFIED			02/09/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 025					
* SOURCE OF TAPE : DEEP DRONE FIXED TAPE 1					
120-150	S/C CYL WEB WITH CURVED UNDEFINED DEBRIS IN BACKGROUND. IT IS WHITE IN COLOR, MAY BE COVERED WITH MLT (NOT RECOVERED)	TDRSS		02/09/86	JOHN PIACENTINI, TRW
150-ON	YPICAL TDRSS DEBRIS - NO UNITS, JUST STRUCTURE, (LARGEST PARTS RECOVERED)	TDRSS		02/09/86	JOHN PIACENTINI, TRW
ALL	NO ORBITER HARDWARE IDENTIFIED			02/09/86	JOE KILGORE, RI LSS

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POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 026					
* SOURCE OF TAPE : DEEP DRONE PAN & TILT					
400	SEPARATION BAND (NOT RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
430	BLACK BOX, CAN'T ID	TDRSS		02/09/86	CHESTER HAMER, TRW
450	MAY BE CROSS SECTION VIEW OF HONEYCOMB EQUIPMENT PLATFORM	TDRSS		02/09/86	CHESTER HAMER, TRW
540	ADAPTER HARNESS (RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
560	UPPER & LOWER S/C MODULE CYLINDER WEB	TDRSS		02/09/86	CHESTER HAMER, TRW
580	SAME AS COUNTER REFERENCE 560 SHOWING STRUT ATTACHED TO S/C PORTION OF SEPARATION RING (RECOVERED CORNER PORTION & STRUTS)	TDRSS		02/09/86	CHESTER HAMER, TRW
590	MLI ATTACHED TO SOMETHING IN BACKGROUND APPEARS TO HAVE SOME CURVATURE TO IT BY THE WAY ITS ROCKING (NOT RECOVERED)	TDRSS		02/09/86	CHESTER HAMER, TRW
ALL	CANNOT IDENTIFY DEBRI, ORBITER OR IUS, POOR QUALITY	-		02/09/86	BOB HILLARD
ALL	NO ORBITER HARDWARE IDENTIFIED			02/09/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 027					
* SOURCE OF TAPE : DEEP DRONE FIXED					
0-193	PORTION OF TDRSS TO IUS ADAPTER SEPARATION RING WITH ONE OF FOUR KICKOFF SPRINGS ATTACHED (SAME AS TAPES 24 & 29??) (RECOVERED LESS SPRINGO	TDRSS		02/09/86	JOHN PIACENTINI, TRW
193-650	IUS DEBRIS	IUS		02/09/86	JOHN PIACENTINI, TRW
ALL	NO ORBITER HARDWARE IDENTIFIED			02/09/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 028					
* SOURCE OF TAPE : DEEP DRONE PAN & TILT TAPE 1					
009-535	AFT SKIRT	SRB		02/12/86	BOB HILLARD
535-END	FORWARD SKIRT	SRB		02/12/86	BOB HILLARD
540	TDRS IUS ADAPTER	TDRS		02/12/86	CHESTER HAMER, TRW
540-900	TDRS IUS ADAPTER HARNESS - WEB, STRUT & SHEET METAL DEBRIS OF 127527 CYLINDER ASSY - S/C MODULE STRUCTURE	TDRSS		02/12/86	CHESTER HAMER
ALL	NO ORBITER HARDWARE IDENTIFIED			02/12/86	JOE KILGORE, RI LSS
ALL	NO ET IDENTIFIED			02/12/86	W. FEAGAN, MMC
** TAPE NUMBER : 029					
* SOURCE OF TAPE : DEEP DRONE PAN & TILT TAPE 2					
0-700	CONTINUATION OF SAME THINGS SEEN IN TAPE 28	TDRSS		02/12/86	CHESTER HAMER, TRW
001-510	FWD SKIRT	SRB		02/12/86	BOB HILLARD
510-609	CANNOT IDENTIFY A RING WITH A SPRING ON END. 1 1/2 DIA 3 TO4 INCHES LONG	SRB		02/12/86	BOB HILLARD
516	PORTION OF TDRS TO IUS ADAPTER SEPARATION RING WITH ONE OF FOUR KICKOFF SPRINGS ATTACHED (A PORTION LIKE THIS HAS BEEN RECOVERED BUT SPRING WAS NOT WITH IT)	TDRSS		02/12/86	CHESTER HAMER, TRW
609-END	SCATTERED DEBRI, THERMAL CURTAINS, THERMAL CURTAIN RETAINERSWHALE BONE, AFT SKIRT RIBS WITH SOME SKIN, BLACK BOX AFT SKIRT STIFFENERS OR FWD??	SRB		02/12/86	BOB HILLARD
ALL	NO ORBITER HARDWARE IDENTIFIED			02/12/86	JOE KILGORE, RI LSS

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** TAPE NUMBER   : 030

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1247
020         TVC FRAME & TUBING WITH FLEXHOSE                  SRB            0 02/18/86 MC COOL, MSFC EP10
051         STIFFENER RING - 90 DEGREES TUNNEL SPLICE AREA    SRB            0 02/18/86 MC COOL, MSFC EP10
071         GLASS PHENOLIC - NOZZLE                           SRB            0 02/18/86 MC COOL, MSFC EP10
102         GLASS PHENOLIC - SKIRT PARTS                      SRB            0 02/18/86 MC COOL, MSFC EP10
138         GLASS & CARBON PHENOLIC - NOZZLE                  SRB            0 02/18/86 MC COOL, MSFC EP10
167         SYSTEMS TUNNEL - BOTTOM UP - AFT BOOSTER (WITH COVER) SRB        0 02/18/86 MC COOL, MSFC EP10
191         EXHAUST DUCT OR TVC TUBING                        SRB            0 02/18/86 MC COOL, MSFC EP10
204         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
235         STIFFENER RING - 90 DEGREES TUNNEL SPLICE ARES    SRB            0 02/18/86 MC COOL, MSFC EP10
320         NOZZLE RING CARBON                                SRB            0 02/18/86 MC COOL, MSFC EP10
340         AFT SKIRT SKIN                                    SRB            0 02/18/86 MC COOL, MSFC EP10
366         CARBON PHENOLIC - NOZZLE                          SRB            0 02/18/86 MC COOL, MSFC EP10
385         SMALL FRAGMENT                                    SRB            0 02/18/86 MC COOL, MSFC EP10
396         PHENOLIC, SMALL PIECE                             SRB            0 02/18/86 MC COOL, MSFC EP10
406         AFT SKIRT FRAGMENT                                SRB            0 02/18/86 MC COOL, MSFC EP10
415         AFT SKIRT FRAGMENT                                SRB            0 02/18/86 MC COOL, MSFC EP10
423         AFT SKIRT SKIN                                    SRB            0 02/18/86 MC COOL, MSFC EP10
436         UNIDENTIFIED RING                                 SRB            0 02/18/86 MC COOL, MSFC EP10
442         CARBON PHENOLIC                                   SRB            0 02/18/86 MC COOL, MSFC EP10
ALL         NO ORBITER HARDWARE IDENTIFIED                                     02/18/86 JOE KILGORE, RI LSS
ALL         NO SPARTAN HALLEY VISABLE                                          02/18/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 031

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1248, TAPE 1
013         PIN RETAINER BAND                                 SRB            0 02/18/86 MC COOL, MSFC EP10
116         CARBON & GLASS PHENOLIC - NOZZLE                  SRB            0 02/18/86 MC COOL, MSFC EP10
177         CARBON PHENOLIC                                   SRB            0 02/18/86 MC COOL, MSFC EP10
187         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
218         CARBON PHENOLIC                                   SRB            0 02/18/86 MC COOL, MSFC EP10
264         LSC SILICONE RETAINER - NO CHARGE                 SRB            0 02/18/86 MC COOL, MSFC EP10
293         TVC BRACKET                                       SRB            0 02/18/86 MC COOL, MSFC EP10
325         PIECE OF CURTAIN WITH RIVET HOLES, GLASS PHENOLIC SRB            0 02/18/86 MC COOL, MSFC EP10
374         SKIN FRAGMENT                                     SRB            0 02/18/86 MC COOL, MSFC EP10
385         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
394         SKIN THERMAL CURTAIN                              SRB            0 02/18/86 MC COOL, MSFC EP10
409         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
427         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
438         CARBON PHENOLIC                                   SRB            0 02/18/86 MC COOL, MSFC EP10
455         SKIRT FRAGMENT                                    SRB            0 02/18/86 MC COOL, MSFC EP10
ALL         NO SPARTAN HALLEY VISIBLE                                          02/18/86 DEAN ZIMMERMAN
ALL         NO ORBITER IDENTIFIED                                              02/18/86 JOE KILGORE

** TAPE NUMBER   : 032

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1248, TAPE 2
011         GLASS PHENOLIC                                    SRB            0 02/18/86 MC COOL, MSFC EP10
145         NOZZLE, 3 FT SQUARE                               SRB              02/18/86 BOB HILLARD
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228          NOZZLE RING, APPROX. 30                                       SRB                 02/18/86 BOB HILLARD
315          NOZZLE (YELLOW)                                               SRB                 02/18/86 BOB HILLARD
402          NOZZLE (YELLOW BAND)                                          SRB                 02/18/86 BOB HILLARD
ALL          NO ET PARTS IDENTIFIED                                                            02/18/86 W. FEAGAN, MMC
ALL          NO ORBITER IDENTIFIED                                                             02/18/86 JOE KILGORE

** TAPE NUMBER   : 033

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1249
025          RH AFT BOOSTER ON SKIRT                                       SRB                 02/18/86 BOB HILLARD
055          SKIN TUNNEL AREA PROPELLANT                                   SRB                 02/18/86 BOB HILLARD
160          SKIN OF SEGMENT W/SYSTEMS TUNNEL AT STIFFENER RING            SRB                 02/18/86 BOB HILLARD
ALL          NO ET PARTS IDENTIFIED                                                            02/18/86 W. FEAGAN, MMC
ALL          NO ORBITER IDENTIFIED                                                             02/18/86 JOE KILGORE

** TAPE NUMBER   : 034

* SOURCE OF TAPE : DEEP DRONE PAN & TILT, 2-16-86 - 2-19-86
001          AFT BOOSTER                                                   SRB                 02/19/86 BOB HILLARD
060          AFT BOOSTER, ETA RING (LH) PARTIAL                            SRB                 02/19/86 BOB HILLARD
ALL          PROBABLE PART OF LH SRM AFT SEGMENT                           SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          CIRC. SECTION OF SRM ET ATTACH RING SEGMENT                   SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          LENGTH FROM FWD FIELD JOINT TO FWD STIFFENER JOINT            SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          SEGMENT SURFACE DOES NOT APPEAR TO BE SOOTED                  SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          INHIBITOR STUB REMAINING APPEAR NORMAL OVER 180 CIRC.         SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          NO PROPELLANT WAS NOTED                                       SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          ET ATTACH RING AFT JOINT HAS HOLES EXPOSED                    SRM              0 02/16/86 K. COATES, MSFC, EE71
ALL          NO ET PARTS IDENTIFIED                                                            02/19/86 W. FEAGAN, MMC
ALL          NO ORBITER IDENTIFIED                                                             02/19/86 JOE KILGORE

** TAPE NUMBER   : 035

* SOURCE OF TAPE : DEEP DRONE FIXED 2-16-86 - 2-19-86
200-END      LH AFT BOOSTER ETA RING SECTION, POOR VISIBILITY              SRB                 02/19/86 BOB HILLARD
ALL          NO ET PARTS IDENTIFIED                                                            02/19/86 W. FEAGAN, MMC
ALL          NO ORBITER IDENTIFIED                                                             02/19/86 JOE KILGORE

** TAPE NUMBER   : 036

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1250 ODC TARGET 26
             SRB SEGMENT CASE W/PROPELLANT                                 SRB                 02/21/86 BOB HILLARD
120          LT WT CASE 1US0717-02, S/N #0000075R1, FACTORY JOINT TANG     SRB                 02/21/86 BOB HILLARD
300-END      SRB SEGMENT CASE W/PROPELLANT FIELD JOINT CLEVIS              SRB                 02/21/86 BOB HILLARD
ALL          NO ET PARTS IDENTIFIED                                                            02/21/86 W. FEAGAN, MMC
ALL          NO ORBITER IDENTIFIED                                                             02/21/86 JOE KILGORE

** TAPE NUMBER   : 037

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1250 ODC #26 TARGET 182
001-296      SRM CASE PIECE  S.N. 0000075R1, PART # 1050717-02 WITH TANG  SRB           182 02/21/86 MH PHILLIPS, MTI  SHERMAN L
             PROPELLANT ABOUT 1.5"-2" THICK.  DEPTH - 234 FT                                            AVARS, MSFC
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                                              UNDERWATER VIDEO LOG
                                                                                 SYSTEM     TARGET   DATE     COMMENTS
POSITION    DESCRIPTION                                                                     NUMBER   TAPE        BY
                                                                                                     RECEIVED

1-296       SRM CASE PIECE S.N. 0000075R1 PART #1050717-02 WITH TANG PRO SRM                     0 02/21/86 S.L. ARANS, MSFC, EP13
296         SRM CASE PIECE INHIBITOR AT JOINT & PROPELLANT GRAIN 2       SRM                     0 02/21/86 S.L. ARANS, MSFC, EP13

* SOURCE OF TAPE : JOHNSON SEALINK II: DIVE #1250 OOC #26 TARGET 182
296-END     SRM CASE PIECE INHIBITER AT JOINT + PROPELLANT GRAIN APPOX.  SRB                   182 02/21/86 MH PHILLIPS, MTI  SHERMAN L
            2" THICK. SHOWS SHAPE CHARGE CUT?  CLEVIS END OUTER LEG                                         AVARS, MSFC
            BROKEN AWAY. 4.5 - 5 FT ARC. LENGTH - 8 FT. DEPTH - 234 FT

* SOURCE OF TAPE : JOHNSON SEALINK II. DIVE #1250 OOC #26 TARGET 182
315         PIECE OF LH SRM STEEL SEGMENT - 8 FT LONG X 4-5 FT CIRCUM    SRB                       02/21/86 C. NIGHSWONGER, MTI
            CLEVIS END OF FIELD JOINT SHOWING WITH INHIBITOR FLAP ALSO
            SOME CHROMATE PUTTY VISIBLE.  PROPELLANT VISIBLE.
315         BASED ON HEIGHT OF INHIBITOR. PART APPEARS TO BE ALSO AFT    SRB                       02/21/86 C. NIGHSWONGER, MTI
            CENTER SEGMENT
470         FWD CASE SEGMENT                                             SRB                       02/21/86 C. NIGHSWONGER, MTI
8           LARGE PIECE OF LH SRM. AFT CTR FWD CASE SEGMENT STEEL        SRB                       02/21/86 C. NIGHSWONGER, MTI
            SEGMENT - 10 FT LONG X 7-8 FT CIRCUM. IDENT S/N 075r1 2" OF
            PROPELLANT VISIBLE ON CASE WALL
ALL         NO ORBITER IDENTIFIED                                                                  02/21/86 JOE KILGORE

** TAPE NUMBER   : 038

* SOURCE OF TAPE : JOHNSON SEALINK II. OOC #3
            APPEARS TO BE PART OF ET - POSSIBLY ET HYDROGEN TANK         ET                        02/22/86 W. FEAGAN, ET
            SECTION.  APPEARS TO HAVE HOLE BURNED THROUGH
ALL         EXTERNAL TAPE SKIN PIECES                                    ET                        02/22/86 S.L. AVANS, MSFC
ALL         NO SHUTTLE PIECES - OLD AIRCRAFT                             -                         02/22/86 S.L. AVANS, MSFC
ALL         NO ORBITER IDENTIFIED                                                                  02/22/86 JOE KILGORE

** TAPE NUMBER   : 039

* SOURCE OF TAPE : JOHNSON SEALINK II. DIVE #1256. OOC #40
ALL         FISH BURROWS AND OLD AIRCRAFT                                                            /  /   BOB HILLARD

** TAPE NUMBER   : 040

* SOURCE OF TAPE : JOHNSON SEALINK II. DIVE #1254. OOC #29
            APPEARS TO BE ET HYDROGEN TANK SECTION.  TAPE 038 COULD BE   ET                        02/22/86 W. FEAGAN, ET
            THAT TORE AWAY AT BOTTOM
ALL         EXTERNAL TANK SKIN PIECE                                     ET                        02/22/86 S.L. AVANS, MSFC
ALL         NO TDRS ID                                                                             02/22/86 CHESTER HAMER, TRW
ALL         NO SPARTAN HALLEY VISIBLE                                                              02/22/86 DEAN ZIMMERMAN
ALL         NO ORBITER IDENTIFIED                                                                  02/22/86 JOE KILGORE

** TAPE NUMBER   : 041

* SOURCE OF TAPE : JOHNSON SEALINK II. DIVE #1257. OOC #41 (J5-1)
250         IGNITER                                                      SRM                     0 02/23/86 S.L. ARANS, MSFC, EP13
ALL         SRM DOME, IGNITER & FWD SKIRT SKIN & CLEVIS TANG 180         SRM                     0 02/23/86 S.L. ARANS, MSFC, EP13
ALL         SRM DOME, IGNITER, & FWD SKIRT                               SRB                       02/23/86 BOB HILLARD
ALL         NO ET PARTS IDENTIFIED                                                                 02/23/86 W. FEAGAN, MMC
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                                                 UNDERWATER VIDEO LOG
POSITION   DESCRIPTION                                               SYSTEM   TARGET   DATE     COMMENTS
                                                                              NUMBER   TAPE        BY
                                                                                       RECEIVED

ALL        NO ORBITER IDENTIFIED                                                       02/23/86 JOE KILGORE

** TAPE NUMBER   : 042

* SOURCE OF TAPE : JOHNSON SEALINK II,DIVE #1257,OOC #41 (CONTINUATION)(J5-2)
190        FORWARD SKIRT AFT CLEVIS TANG                             SRM             0 02/23/86 S.L. ARANS, MSFC EP13
198        FORWARD DOME WITH IGNITER                                 SRM             0 02/23/86 S.L. ARANS, MSFC EP13
200        IGNITER                                                   SRM             0 02/23/86 S.L. ARANS, MSFC EP13
ALL        SRM DOME, IGNITER & FWD SKIRT SKIN & CLEVIS TANG 180      SRM             0 02/23/86 S.L. ARANS, MSFC EP13
ALL        SRM DOME,IGNITER & FWD SKIRT                              SRB               02/23/86 BOB HILLARD
ALL        NO ET PARTS IDENTIFIED                                                      02/23/86 W. FEAGAN, MMC
ALL        NO ORBITER IDENTIFIED                                                       02/23/86 JOE KILGORE

** TAPE NUMBER   : 043

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, TAPE 1 OF 6
ALL        POOR QUALITY, NOT USEFUL FOR IDENTIFICATION OF H/W        -               0 02/20/86 SHERMAN ARANS, MSFC EP13

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 1 OF 6
ALL        NO ET IDENTIFIED                                                            02/19/86 W. FEAGAN, MMC
ALL        NO SPARTAN HALLEY VISIBLE                                                   02/19/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 044

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 2 OF 6
           SCATTERED DEBRI?  VERY POOR VISABILITY                    SRB               02/19/86 BOB HILLARD

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, TAPE 2 OF 6
ALL        POOR QUALITY                                              -               0 02/20/86 SHERMAN ARANS, MSFC EP13

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 2 OF 6
ALL        NO ET IDENTIFIED                                                            02/19/86 W. FEAGAN, MMC
ALL        NO SPARTAN HALLEY VISIBLE                                                   02/19/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 045

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, TAPE 3 OF 6
ALL        POOR QUALITY                                              -               0 02/20/86 SHERMAN ARANS, MSFC EP13

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 3 OF 6
ALL        NO ORBITER HARDWARE IDENTIFIED                                              02/19/86 JOE KILGORE, RI LSS
ALL        NO SPARTAN HALLEY VISIBLE                                                   02/19/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 046

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, TAPE 4 OF 6
ALL        POOR QUALITY                                              -               0 02/20/86 SHERMAN ARANS, MSFC EP13

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 4 OF 6
ALL        NO ORBITER HARDWARE IDENTIFIED                                              02/19/86 JOE KILGORE, RI LSS
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                                                 UNDERWATER VIDEO LOG
                                                                                   SYSTEM    TARGET   DATE      COMMENTS
POSITION     DESCRIPTION                                                                     NUMBER   TAPE        BY
                                                                                                      RECEIVED

** TAPE NUMBER   : 047

* SOURCE OF TAPE : DEEP DRONE FIXED. TARGET 2 & 37. TAPE 5 OF 6                    _              0 02/19/86 M H PHILLIPS.L R JENSON. MTI
ALL          POOR QUALITY

* SOURCE OF TAPE : DEEP DRONE FIXED. TARGET 2 & 37. 5 OF 6                                         02/19/86 JOE KILGORE. RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED

** TAPE NUMBER   : 048

* SOURCE OF TAPE : DEEP DRONE FIXED. TARGET 2 & 37. TAPE 6 OF 6                    _              0 02/19/86 M H PHILLIPS.L R JENSON. MTI
ALL          NO H/W LOCATED ON TAPE

* SOURCE OF TAPE : DEEP DRONE FIXED. TARGET 2 & 37. 6 OF 6                                         02/19/86 JOE KILGORE. RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED

** TAPE NUMBER   : 049

* SOURCE OF TAPE : NR-1. TAPE #5 (DUPLICATE OF TAPE #057)                                         0 02/22/86 MH PHILLIPS. MTI. PAT
0165-1780    CONTACT 82-87 SMALL PIECES. NOT IDENTIFIABLE                          _                         PATTERSON. MSFC
                                                                                                  0 02/22/86 MH PHILLIPS. MTI. PAT
1789-1830    CONTACT 17 FROM PREVIOUS TAPE. HYDRAZINE BOTTLE                       SRB                       PATTERSON. MSFC
                                                                                                  0 02/22/86 MH PHILLIPS. MTI  PAT
2100-3400    CONTACT #1 FROM PREVIOUS TAPE - AFT 1/3 OF AFT MOTOR CASE OR SRB                                PATERSON. MSFC
             AFT SKIRT SEGMENT RIGHT SRB @ 10:28                                   _              0 02/22/86 MH PHILLIPS. MTI  PAT
3457         GLOVE - CONTACT 89  12:09 HOURS                                                                 PATERSON. MSFC
                                                                                   _              0 02/22/86 MH PHILLIPS. MTI  PAT
4160         CONTACT 91 - SMALL PIECE OF METAL                                                               PATERSON. MSFC
                                                                                   SRB            0 02/22/86 MH PHILLIPS. MTI  PAT
4300         4x4 FT PIECE OF SRM SKIN W/TUNNEL. POSS. PART OF 3RD                                            PATERSON. MSFC
             STIFFNER RING BLACKENED 1285 DEPTH POSS. W/FACTORY JOINT IN
             MIDDLE. MID & UPPER STIFFENER RING PIECES.CABLES IN TUNNEL
             SECTION                                                                              0 02/22/86 MH PHILLIPS. MTI  PAT
4950-END     CABLE. CONTACT 94. POSSIBLY WITH STRAP. TIME 14:02 HOURS              SRB                       PATERSON. MSFC

** TAPE NUMBER   : 050

* SOURCE OF TAPE : DEEP DRONE. PAN & TILT. TARGET 2 & 37. 2/19/86. 1 OF 3                            02/19/86 BOB HILLARD
             CANNOT IDENTIFY                                                       _                  02/19/86 CHESTER HAMER. TRW
ALL          NO TDRS ID                                                                               02/19/86 DEAN ZIMMERMAN
ALL          NO SPARTAN HALLEY VISIBLE                                                                02/19/86 JOE KILGORE
ALL          NO ORBITER IDENTIFIED

** TAPE NUMBER   : 051

* SOURCE OF TAPE : DEEP DRONE. PAN & TILT. TARGET 2 & 37. 2/19-2/20. 2 OF 3                          02/19/86 BOB HILLARD
             SCATTERED DEBRI. CANNOT IDENTIY                                       _                  02/19/86 CHESTER HAMER. TRW
ALL          NO TDRS ID                                                                               02/19/86 DEAN ZIMMERMAN
ALL          NO SPARTAN HALLEY VISIBLE                                                                02/19/86 JOE KILGORE
ALL          NO ORBITER IDENTIFIED
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                                                   UNDERWATER VIDEO LOG
POSITION     DESCRIPTION                                                   SYSTEM     TARGET   DATE      COMMENTS
                                                                                      NUMBER   TAPE         BY
                                                                                               RECEIVED

** TAPE NUMBER   : 052

* SOURCE OF TAPE : DEEP DRONE, PAN & TILT, TARGET 2 & 37, 2/19-2/20, 3 OF 3
ALL          SCATTERED DEBRI, CANNOT IDENTIFY                                -                 02/19/86 BOB HILLARD
ALL          NO TDRS ID                                                      -                 02/19/86 CHESTER HAMER, TRW
ALL          NO SPARTAN HALLEY VISIBLE                                                         02/19/86 DEAN ZIMMERMAN
ALL          NO ORBITER IDENTIFIED                                                             02/19/86 JOE KILGORE

** TAPE NUMBER   : 053

* SOURCE OF TAPE : NR-1, TAPE #1, ID #001, AREA A
0500-2220    CONTACT #1, 28 49 14 N, 79 52 39 W, AFT SEGMENT SITTING ON    SRB                 02/20/86 J. JENSEN, MTI
             AFT SKIRT
2872         3 STIFFENER RINGS 41 CLEVIS - SPREAD OPEN JOINTS BROKEN       SRB                 02/20/86 J. JENSEN, MTI
2872         APPEARS TO BE INSIDE OF SKIRT                                 SRB                 02/20/86 J. JENSEN, MTI
2872         PAT COMMENT.  WOULD PROBABLY BREAK UP WHEN LIFTED             SRB                 02/20/86 J. JENSEN, MTI
4107         UNDENTIFIED CIRCULAR OBJECT                                                       02/20/86 J. JENSEN, MTI
4359         TWISTED WRECKAGE                                                                  02/20/86 J. JENSEN, MTI
4706         NOZZLE THROAT, LOOKING DOWN 12-15 FT ACROSS X 6-7 FT OFF      SRB                 02/20/86 J. JENSEN, MTI
             SURFACE
5580         BOOSTER SEPARATION MOTOR ON PIECE OF AFT SKIRT                SRB                 02/20/86 BOB SAIOLA, USBI
ALL          RH AFT BOOSTER (PORTION) AND SCATTERED DEBRI                  SRB                 02/20/86 BOB HILLARD
ALL          NO ORBITER HARDWAE IDENTIFIED                                                     02/20/86 JOE KILGORE, RI LSS
ALL          NO ET IDENTIFIED                                                                  02/20/86 W. FEAGAN, MMC

** TAPE NUMBER   : 054

* SOURCE OF TAPE : NR-1, TAPE #2, ID #001, AREA A
0000-0140    FORWARD FIXED HOUSING (NOZZLE) CONTACT #8                     SRB                 02/21/86 PAT PATTERSON, MTI
1150         CONTACT #10, AFT BOOSTER                                      SRB                 02/21/86 PAT PATTERSON, MTI
1328         CONTACT 11                                                    SRB                 02/21/86 PAT PATTERSON, MTI
ALL          NO TDRS ID                                                    -                   02/21/86 CHESTER HAMER, TRW

** TAPE NUMBER   : 055

* SOURCE OF TAPE : NR-1, TAPE #3, ID #001 AREA A
ALL          POOR VIDEO, POOR VISABILITY                                   -                   02/21/86 BOB HILLARD
ALL          NO ORBITER HARDWARE IDENTIFIED                                                    02/21/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 056

* SOURCE OF TAPE : NR-1, TAPE #4, ID #001, AREA A
20           PIECES OF NOZZLE                                              SRB                 02/21/86
ALL          VARIOUS SCATTERED DEBRI, NOZZLE                               SRB                 02/21/86 BOB HILLARD
ALL          NO ORBITER HARDWARE IDENTIFIED                                                    02/21/86 JOE KILGORE, RI LSS
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POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 057					
* SOURCE OF TAPE : NR-1, TAPE #5, ID #001, AREA A					
ALL	SCATTERED DEBRIS, NOZZLE	SRB		02/22/86	BOB HILLARD
ALL	NO ORBITER HARDWARE IDENTIFIED			02/22/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 058					
* SOURCE OF TAPE : NR-1, TAPE #6, ID #001, AREA A					
1250-1405	AFT SKIRT, ACTUATOR ROD BURIED IN SAND, ACTUATOR STIFFENER IN SKIRT	SRB		02/22/86	BOB HILLARD
2660	BUNDLE OF RINGS?? NOT CLEAR	SRB		02/22/86	BOB HILLARD
ALL	NO ORBITER HARDWARE IDENTIFIED			02/22/86	JOE KILGORE, RI LSS
** TAPE NUMBER : 059					
* SOURCE OF TAPE : NR-1, TAPE #7, ID #001, AREA A					
1850	12 FT SQ WHITE SQUARE PIKE			02/02/86	BOB HILLARD
1894	12 FT SQ WHITE SQUARE PIKE			02/02/86	BOB HILLARD
1894	JAGGED METAL			02/02/86	BOB HILLARD
2030	6' X 6' PIECE OF METAL			02/02/86	BOB HILLARD
2140	CONTROL ROD 12" DIA SPARTAN HALEY?			02/02/86	BOB HILLARD
2245	HYDRAZINE TANK	SRB		02/22/86	W.F. IMRE, USBI-BPC
2270	HYDRAZINE BOTTLE 8' LONG OBJECT	SRB		02/02/86	BOB HILLARD
2395	HYDRAULIC RESERVOIR	SRB		02/22/86	W.F. IMRE, USBI-BPC
2479	RUTURED VIEW OF HYDRAZINE TANK	SRB		02/22/86	W.F. IMRE, USBI-BPC
2580	HYDRAZINE BOTTLE (RUPTURED) WITH HYDRAULIC ACTUATOR	SRB		02/02/86	BOB HILLARD
2585	VIEW OF TVC FRAME AND HYDRAULIC RESERVOIR	SRB		02/22/86	W.F. IMRE, USBI-BPC
2639	VIEW OF HYDRAULIC RESERVOIR (CLOSE UP)	SRB		02/22/86	W.F. IMRE, USBI-BPC
2660	TVC LOWER FRAME (CLOSE UP)	SRB		02/22/86	W.F. IMRE, USBI-BPC
2880	HYDRAULIC ACTUATOR	SRB		02/02/86	BOB HILLARD
2959	NOZZLE PART CONTACT #148	SRB		02/22/86	W.F. IMRE, USBI-BPC
3060	SKIN 3' X 8' SEGMENT CONTACT #149	SRB		02/22/86	W.F. IMRE, USBI-BPC
3145	WHITE BAR 4' LONG 6" WIDTH			02/02/86	BOB HILLARD
3185	NOZZLE PART 5' DIA 200 COMPLETE	SRB		02/02/86	BOB HILLARD
3300	3' X 8' SKIN	SRB		02/02/86	BOB HILLARD
3370	AFT SKIRT SKIN WITH CABLES AND COMPONENT IDENTIFIED AS ACTUATOR	SRB		02/22/86	W.F. IMRE, USBI-BPC
3496	PILE OF DEBRIS ACTUATOR	SRB		02/02/86	BOB HILLARD
3815	CONTACT PREVIOUSLY SEEN			02/02/86	BOB HILLARD
4030	LARGE MASS OF METAL ACTUATOR	SRB		02/02/86	BOB HILLARD
4390	ACTUATOR?	SRB		02/02/86	BOB HILLARD
4540	ACTUATOR	SRB		02/02/86	BOB HILLARD
4613	120 NOZZLE PART, HEAVY PIECE LEFT CRATER IN SAND	SRB		02/02/86	BOB HILLARD
4760	NOZZLE PART	SRB		02/22/86	W.F. IMRE, USBI-BPC
4910	RING	SRB		02/02/86	BOB HILLARD
4990	2' X 4' PIECE	SRB		02/02/86	BOB HILLARD
5085	I BEAM TYPE MATERIAL	SRB		02/02/86	BOB HILLARD
5125	PORTION OF SKIRT	SRB		02/02/86	BOB HILLARD
5235	SKIN PIECE FOLDED DIA APPROX 4'	SRB		02/02/86	BOB HILLARD
5238	NOZZLE PART 360 INTACT AROUND	SRB		02/22/86	W.F. IMRE, USBI-BPC

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                                   UNDERWATER VIDEO LOG

POSITION   DESCRIPTION                                                 SYSTEM    TARGET   DATE     COMMENTS
                                                                                 NUMBER   TAPE       BY
                                                                                          RECEIVED

5250       CIRCULAR PIECE 270 INTACT (NOZZLE RING)                      SRB               02/22/86 W.F. IMRE, USBI-BPC
5325       8' LONG SKIN                                                 SRB               02/02/86 BOB HILLARD
5335       10' X 6' PARTIALLY COVERED WITH SAND                         SRB               02/02/86 BOB HILLARD
5590       15' LONG NOZZLE PIECE COMPLETE 180                           SRB               02/02/86 BOB HILLARD
ALL        NO ORBITER IDENTIFIED                                                          02/22/86 JOE KILGORE

** TAPE NUMBER   : 060

* SOURCE OF TAPE : NR-1, TAPE #8, ID #001, AREA A
0130       3' X 4' AFT SKIRT                                            SRB               02/22/86 BOB HILLARD
0487       3'X4' AFT SKIRT                                              SRB               02/22/86 BOB HILLARD
0575       10'X4' YELLOW OBJECT                                                           02/22/86 BOB HILLARD
0715       LARGE PLATE APPROX 20 FT SQ (SEE TAPE POSITION 1637)                           02/22/86 BOB HILLARD
1637       MOTOR SKIN & CONTINUED FROM TAPE POSITION 1637 TILL 2295     SRB               02/22/86 BOB HILLARD
2212       PORTION OF A RING SIGHTED AND "IN" CLIPS                     SRB               02/22/86 BOB HILLARD
2493       SMALL PIECE OF SKIN                                                            02/22/86 BOB HILLARD
2615       12'X8' SRB SKIN STIFFENER RING WAS LOCATED IN THE AREA BY    SRB               02/22/86 BOB HILLARD
           WHITE LINE.  SURFACE OF SKIN APPEARS CHARRED
2920       NOZZLE PARTS, COMPLIANCE RING                                SRB               02/22/86 BOB HILLARD
3280       UNKNOWN ITEM                                                                   02/22/86 BOB HILLARD
3730       WHALE BONE, SNUBBER                                          SRB               02/22/86 BOB HILLARD
3940       1' LONG 6" WIDE                                              SRB               02/22/86 BOB HILLARD
4120       6' DIAMETER CARBON MATERIAL FROM NOZZLE                      SRB               02/22/86 BOB HILLARD
4320       NOZZLE PIECE                                                 SRB               02/22/86 BOB HILLARD
5021       4' WIDE 20' IN LENGTH NOZZLE MATERIAL                        SRB               02/22/86 BOB HILLARD
5143       COMPLETE 360 FANALIC MATERIAL                                SRB               02/22/86 BOB HILLARD
ALL        NO ORBITER HARDWARE IDENTIFIED                                                 02/22/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 061

* SOURCE OF TAPE : NR-1, TAPE #9, ID #001, AREA A
0330       AFT SKIRT PIECE                                              SRB               02/23/86 DENNIS CRAWFORD
0699       I BEAM FROM BULKHEAD                                         SRB               02/23/86 DENNIS CRAWFORD
0945       RING COMPLETE NOZZLE MATERIAL                                SRB               02/23/86 DENNIS CRAWFORD
1035       HYDRAZINE BOTTLE, PREVIOUSLY SEEN                            SRB               02/23/86 DENNIS CRAWFORD
1494       DEBRI                                                        SRB               02/23/86 DENNIS CRAWFORD
1690       CRUMPLED INSULATION MATERIAL                                 SRB               02/23/86 DENNIS CRAWFORD
2045       SKIRT WITH CONTROLS                                          SRB               02/23/86 DENNIS CRAWFORD
2050       BOOSTER SNUBBER, TWISTED METAL                               SRB               02/23/86 DENNIS CRAWFORD
2360       TEN FEET LONG                                                SRB               02/23/86 DENNIS CRAWFORD
2777       NOZZLE RING                                                  SRB               02/23/86 DENNIS CRAWFORD
3256       SEGMENT SKIN, APPEARED CHARRED                               SRB               02/23/86 DENNIS CRAWFORD
3600       PIECE OF MATERIAL 5' WIDE 4' LONG                            SRB               02/23/86 DENNIS CRAWFORD
3600       PIECE OF I BEAM                                              SRB               02/23/86 DENNIS CRAWFORD
3895       10' PIECE                                                    SRB               02/23/86 DENNIS CRAWFORD
4460       PIECE OF PIPE AND 2 FT SQ PIECE OF MATERIAL                  SRB               02/23/86 DENNIS CRAWFORD
4550       TWO PIECES OF NOZZLE MATERIAL                                SRB               02/23/86 DENNIS CRAWFORD
ALL        NO ORBITER HARDWARE IDENTIFIED                                                 02/23/86 JOE KILGORE, RI LSS
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UNDERWATER VIDEO LOG

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 062					
* SOURCE OF TAPE : NR-1, TAPE #10, ID #001, AREA A					
1005	CONTACT 268 190 RING MAT'L NOZZLE	SRB		02/23/86	W.F. IMRE, USBI-BPC
1760	CONTACT 271, BLACK RING NOT IN VIEW	SRB		02/23/86	W.F. IMRE, USBI-BPC
3003	CONTACT 281 SKIN MATERIAL 2' X 3'	SRB		02/23/86	W.F. IMRE, USBI-BPC
4451	CONTACT 287, RING DIA 5' TO 6'	SRB		02/23/86	W.F. IMRE, USBI-BPC
4700	CONTACT 290, 10' X 10' SKIN MATERIAL, POSSIBLE ONE OF FWD SEGMENTS TANG JOIN	SRB		02/23/86	W.F. IMRE, USBI-BPC
5438	LOST VISUAL CONTACT MAINTAINED AUDIO	SRB		02/23/86	W.F. IMRE, USBI-BPC
ALL	NO ORBITER IDENTIFIED			02/23/86	JOE KILGORE
** TAPE NUMBER : 063					
* SOURCE OF TAPE : NR-1, TAPE #11, ID #001, AREA A					
2290	2' X 3' CHUNK REMOVED FROM ONE CORNER			02/23/86	BOB HILLARD
2290	2' X 3'6' CHUNK REMOVED FROM ONE CORNER			02/23/86	DENNIS CRAWFORD
2565	SMALL DARK GRAY PIECE			02/23/86	BOB HILLARD
2565	SMALL DARK GRAY PIECE			02/23/86	DENNIS CRAWFORD
2565	SMALL DARK GRAY PIECE			02/23/86	DENNIS CRAWFORD
3155	SMALL BLACK DEBRIS			02/23/86	BOB HILLARD
3155	SMALL BLACK DEBRIS			02/23/86	DENNIS CRAWFORD
3300	WHITE MATERIAL BENT ON ITSELF 4' LONG BY 4" WIDE			02/23/86	BOB HILLARD
3300	WHITE MATERIAL BENT ON ITSELF 4' LONG BY 4" WIDE			02/23/86	DENNIS CRAWFORD
4066	CURVED BLACK PIECE			02/23/86	BOB HILLARD
4066	CURVED BLACK PIECE			02/23/86	DENNIS CRAWFORD
ALL	POSSIBLE SRB - MISC DEBRIS	SRB		02/23/86	BOB HILLARD
ALL	VIDEO WAS POOR IN TERMS OF MAJOR DEBRIS FINDINGS AND VISUAL QUALITY	SRB		02/23/86	BOB HILLARD
ALL	NO ORBITER IDENTIFIED			02/23/86	JOE KILGORE
** TAPE NUMBER : 064					
* SOURCE OF TAPE : DEEP DRONE P&T, TGT 37, OTV 42, TGT 10, 2/22/86, 1 OF 2					
1000	STRUT POSSIBLE ORBITER AFT BORON STRUT APPROX 2 DIA, OTHER DEBRIS NOT IDENTIFIABLE	ORBITER		02/22/86	JOE KILGORE, RILSS
ALL	SCATTERED DEBRIS, COULD NOT IDENTIFY AS SRB			02/22/86	BOB HILLARD
ALL	NO TDRS ID			02/22/86	CHESTER HAMER, TRW
ALL	MOSTLY OLD DEBRIS - NO ET IDENTIFIED			02/22/86	W. FEAGAN, MMC
ALL	NO SPARTAN HALLEY VISIBLE			02/22/86	DEAN ZIMMERMAN
** TAPE NUMBER : 065					
* SOURCE OF TAPE : DEEP DRONE P&T, TGT 37, OTV 42, TGT 10, 2/22/86, 2 OF 2					
ALL	MOSTLY OLD DEBRIS - NO ET IDENTIFIED			02/22/86	W. FEAGAN, MMC
ALL	NO ORBITER IDENTIFIED			02/22/86	JOE KILGORE

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                                                      UNDERWATER VIDEO LOG

POSITION      DESCRIPTION                                                    SYSTEM      TARGET     DATE       COMMENTS
                                                                                         NUMBER     TAPE         BY
                                                                                                    RECEIVED

** TAPE NUMBER    : 066

* SOURCE OF TAPE : DEEP DRONE FIXED. OTV 41. TGT 10. 2/22/86
ALL           POOR VISIBILITY. COULD NOT IDENTIFY AS SRB                       -                    02/22/86 BOB HILLARD
ALL           NO ET PARTS IDENTIFIED                                                                02/22/86 W. FEAGAN. MMC
ALL           NO SPARTAN HALLEY VISIBLE                                                             02/22/86 DEAN ZIMMERMAN
ALL           NO ORBITER IDENTIFIED                                                                 02/22/86 JOE KILGORE

** TAPE NUMBER    : 067

* SOURCE OF TAPE : DEEP DRONE. TGT 37. OTV 41. TGT 10. 2/22/86
ALL           OLD AIRCRAFT. CLOUDY. POOR VISIBILITY. CANNOT IDENTIFY AS        -                    02/22/86 BOB HILLARD
              SRB
ALL           NO ET PARTS IDENTIFIED                                                                02/22/86 W. FEAGAN. MMC
ALL           NO SPARTAN HALLEY VISIBLE                                                             02/22/86 DEAN ZIMMERMAN
ALL           NO ORBITER IDENTIFIED                                                                 02/22/86 JOE KILGORE

** TAPE NUMBER    : 068

* SOURCE OF TAPE : TAPE J6-1. TARGET #24. OOC#24. 2/24/86
175           10182-0092-101 NUMBER FROM SYSTEM TUNNEL PART ON/IN BOOSTER     SRB                  02/24/86 W.F. IMRE. USBI-BPC
              TAIL SECTION

* SOURCE OF TAPE : JSL II. TAPE J6-1. TARGET #24. OOC#24. 2/24/86
213           KICK RING ON AFT SEGMENT                                         SRB                  02/24/86 W.F. IMRE. USBI-BPC
ALL           NO SPARTAN HALLEY VISIBLE                                                             02/24/86 DEAN ZIMMERMAN
ALL           NO ORBITER IDENTIFIED                                                                 02/24/86 JOE KILGORE
ALL           NO ORBITER IDENTIFIED                                                                 02/24/86 JOE KILGORE

** TAPE NUMBER    : 069

* SOURCE OF TAPE : SEALINK II. J6-3. OOC#24. 2/24/86
100           RETRIEVED BOLT FROM ON TOP OF KICK RING PHENOLIC                 SRB                  02/24/86 W.F. IMRE. USBI-BPC
155           FEED THRU SYSTEM TUNNEL COVER/FLOOR ASSEMBLY                     SRB                  02/24/86 W.F. IMRE. USBI-BPC

* SOURCE OF TAPE : SEALINK II. J6-3. OOC #24. 2/24/86
ALL           NO SPARTAN HALLEY VISIBLE                                                             02/24/86 DEAN ZIMMERMAN
ALL           NO ORBITER IDENTIFIED                                                                 02/24/86 JOE KILGORE

** TAPE NUMBER    : 070

* SOURCE OF TAPE : JSL II. J6-2. 2/24/86
100           AFT SEGMENT ABOVE KICK RING WITHOUT PHENOLIC COVERS              SRB                  02/24/86 W.F. IMRE. USBI-BPC

* SOURCE OF TAPE : J6-2. 2/24/86
105           AFT FEED THRU ABOVE KICK RING ON AFT SEGMENT                     SRB                  02/24/86 W.F. IMRE. USBI-BPC
350           SYSTEM TUNNEL AT KICK RING ON AFT SEGMENT                        SRB                  02/24/86 W.F. IMRE. USBI-BPC
363           AFT SKIRT KICK RING PHENOLIC ON AFT SEGMENT                      SRB                  02/24/86 W.F. IMRE. USBI-BPC

* SOURCE OF TAPE : JSL II. J6-2. 2/24/86
ALL           NO SPARTAN HALLEY VISIBLE                                                             02/24/86 DEAN ZIMMERMAN
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                                      UNDERWATER VIDEO LOG
                                                                      DATE      COMMENTS
                                                  SYSTEM    TARGET    TAPE         BY
POSITION     DESCRIPTION                                    NUMBER    RECEIVED

                                                                      02/24/86 JOE KILGORE
ALL          NO ORBITER IDENTIFIED

** TAPE NUMBER    : 071

* SOURCE OF TAPE : DEEP DRONE, P&T, DIVE #29, OOC #56                 03/02/86 BOB HILLARD
ALL          POOR VISIBILITY, CLOUDY                                  03/02/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           03/02/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED

** TAPE NUMBER    : 072

* SOURCE OF TAPE : DEEP DRONE, DIVE #29, FIXED, OOC #56               03/02/86 BOB HILLARD
             STRUCTURE THIN SKINNED W/RIBS CANNOT IDENTIFY  SRB       03/02/86 JOE KILGORE
1500         ORBITER MIDBODY SIDEWALL OR FLOOR                        03/02/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           03/02/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED

** TAPE NUMBER    : 073

* SOURCE OF TAPE : DEEP DRONE, DIVE #30, FIXED, OOC #44     -         03/03/86 BOB HILLARD
             CLOUDY, COULD NOT IDENTIFY                               03/03/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           03/03/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED

** TAPE NUMBER    : 074

* SOURCE OF TAPE : DEEP DRONE, DIVE #30, P&T, OOC #44       -         03/03/86 BOB HILLARD
0-2000       CLOUDY, POOR VISIBILITY                        -         03/03/86 BOB HILLARD
2015         STRUCTURE - COULD NOT IDENTIFY                 -         03/03/86 BOB HILLARD
2450         SHIP? CRUSTY, A LOT OF SEA GROWTH                        03/03/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           03/03/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED

** TAPE NUMBER    : 075

* SOURCE OF TAPE : DEEP DRONE, CONTACT #11, PAN & TILT                03/03/86 BOB HILLARD
             LEFT AFT BOOSTER WITH ETA RING, IDENTIFIED IN EARLIER TAPES, SRB
             FIRST TARGET TO BE RETRIEVED, TAPE 008 AND 035           03/03/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           03/03/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED

** TAPE NUMBER    : 076

* SOURCE OF TAPE : DEEP DRONE, CONTACT #11                            03/03/86 BOB HILLARD
             LEFT AFT BOOSTER WITH ETA RING, IDENTIFIED IN EARLIER TAPES. SRB
             FIRST TARGET TO BE RETREIVED, TAPE 008 AND 035           02/16/86 JOE KILGORE, RI LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                           02/16/86 W. FEAGAN, MMC
ALL          NO ET PARTS IDENTIFIED
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                                                UNDERWATER VIDEO LOG

POSITION    DESCRIPTION                                                SYSTEM       TARGET   DATE     COMMENTS
                                                                                    NUMBER   TAPE       BY
                                                                                             RECEIVED


** TAPE NUMBER   : 077

* SOURCE OF TAPE : FIXED VIDEO, CONTACT #55
            THIN SKINNED STRUCTURE WITH RIBS. CANNOT IDENTIFY          SRB                   03/01/86 BOB HILLARD
ALL         NO ORBITER HARDWARE IDENTIFIED                                                   03/01/86 JOE KILGORE, RI LSS
ALL         NO ET PARTS IDENTIFIED                                                           03/01/86 W. FEAGAN, MMC
ALL         NO SPARTAN HALLEY VISIBLE                                                        03/01/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 078

* SOURCE OF TAPE : PAN & TILT, CONTACT #55
            SAME AS 077, THIN SKINNED STRUCTURE WITH RIBS, CANNOT      SRB                   03/01/86 BOB HILLARD
            IDENTIFY
ALL         NO ORBITER HARDWARE IDENTIFIED                                                   03/01/86 JOE KILGORE, RI LSS
ALL         NO ET PARTS IDENTIFIED                                                           03/01/86 W. FEAGAN, MMC
ALL         NO SPARTAN HALLEY VISIBLE                                                        03/01/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 079

* SOURCE OF TAPE : NR-1, TAPE #12, OTV 54
                                                                       SRB                   02/27/86 W. F. IMRE
                                                                       SRB                   02/27/86 W. F. IMRE
                                                                       SRB                   02/27/86 W. F. IMRE
1060        6' LONG GLASS PHENOLIC STRIP                               SRB                   02/27/86 DENNIS CRAWFORD
1085        55 GAL DRUM                                                SRB                   02/27/86 DENNIS CRAWFORD
2023        PHENOLIC AND CARBON STRIP                                  SRB                   02/27/86 DENNIS CRAWFORD
2451        1 FT DIA PIPE ELBOW, 8 FT LONG                             SRB                   02/27/86 DENNIS CRAWFORD
2520        90 DEGREE ARC, 12' LONG WHITE RING, POSSIBLE STIFFENER RIB SRB                   02/27/86 DENNIS CRAWFORD
            ON FWD SKIRT
2600        90 DEGREE ARC OF CLEAN WHITE METAL.  POSSIBLE INVER RING   SRB                   02/27/86 W. F. IMRE
            SECTION FROM FWD SKIRT
445         4 FT LONG BY 1 FT WIDE PHENOLIC AND CARBON STRIP           SRB                   02/27/86 DENNIS CRAWFORD
825         TWO PHENOLIC & CARBON STRIPS, 2 TO 3 FT LONG               SRB                   02/27/86 DENNIS CRAWFORD
860         60 ARCH RING 6" BY 10' TO 12' LONG                         SRB                   02/27/86 DENNIS CRAWFORD
ALL         NO ORBITER HARDWARE IDENTIFIED                                                   02/27/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 080

* SOURCE OF TAPE : NR-1, TAPE #13, OTV 55
0025        JAGGED METAL (TRIANGLE) 3 FT LONG 8" WIDE                                        02/27/86 BOB HILLARD
0580-0749   DARK BROWN OR BLACK WHITE COATING, BROKEN EDGES, 8 FT LONG,                      02/27/86 BOB HILLARD
            6 FT TALL/WIDE, APPROX 1" THICK, PARTIALLY COVERED WITH SILT
ALL         NO ORBITER HARDWARE IDENTIFIED                                                   02/27/86 JOE KILGORE, RI LSS

** TAPE NUMBER   : 081

* SOURCE OF TAPE : DEEP DRONE DIVE #32 & 33, OOC #3 & OOC #4, P&T
1123        SKIN STUCTURE WITH RIBS VERITICALLY & HORIZONTALLY         TDRSS                 03/04/86 BOB HILLARD
1200        SKIN STRUCTURE WITH RIBS VERTICALLY & HORIZONTALLY, APPROX 2 TDRSS               03/04/86 BOB HILLARD
            TO 3 FT SQUARE
1310        JAGGED PIECE WHITE IN COLOR PARTIALLY COVERED WITH SILT.   TDRSS                 03/04/86 BOB HILLARD
            POSSIBLY AIRCRAFT
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                                                  UNDERWATER VIDEO LOG

POSITION     DESCRIPTION                                              SYSTEM      TARGET   DATE      COMMENTS
                                                                                  NUMBER   TAPE         BY
                                                                                           RECEIVED

2017-2900    STRUCTURE IDENTIFIED IN EARLIER TAPE AS ET               TDRSS                03/04/86 BOB HILLARD
ALL          SAME DIVE AS TAPE #82                                    SRB                  03/04/86 J.A. MACNAB, MMC/LSS
ALL          NO ORBITER HARDWARE IDENTIFIED                                                03/04/86 JOE KILGORE, RI LSS
ALL          NO ET IDENTIFIED                                                              03/04/86 W. FEAGAN, MMC
ALL          NO SPARTAN HALLEY VISIBLE                                                     03/04/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 082

* SOURCE OF TAPE : DEEP DRONE, DIVE #32 & 33, OOC #3 AND OOC #4, FIXED
                                                                                           03/04/86 W. FEAGAN, MMC
1045         STRUCTURE IDENTIFED IN PREVIOUS TAPE AS ET               ET                   03/04/86 DENNIS CRAWFORD
710          METAL SKIN, 2 FT X 1 1/2 FT, TORN EDGES, REINFORCED RIBS ON  SRB              03/04/86 DENNIS CRAWFORD
             BACK SIDE OF SKIN
ALL          NO ORBITER HARDWARE IDENTIFIED                                                03/04/86 JOE KILGORE, RI LSS
ALL          NO ET IDENTIFIED                                                              03/04/86 W. FEAGAN, MMC
ALL          NO SPARTAN HALLEY VISIBLE                                                     03/04/86 DEAN ZIMMERMAN
ALL          NO IDENTIFIABLE ET.                                      ORBITER              03/04/86 J. MACNAB

** TAPE NUMBER   : 083

* SOURCE OF TAPE : DEEP DRONE, CONTACT # 8 & 9, FIXED
ALL          NO TDRS ID                                                                     /  /    CHESTER HAMER, TRW
ALL          MISCELLANEOUS SRB DEBRIS                                 SRB                  03/10/86 CHESTER HAMER
ALL          POSSIBLE AFT FUSELAGE SIDEWALL                                                03/10/86 JOE KILGORE, RI LSS
ALL          NO ET IDENTIFIED                                                              03/10/86 W. FEAGAN, MMC
ALL          NO SPARTAN HALLEY VISIBLE                                                     03/10/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 084

* SOURCE OF TAPE : DEEP DRONE, CONTACT # 8 & 9, P&T
ALL          NO TDRS ID                                                                    03/10/86 CHESTER HAMER, TRW

* SOURCE OF TAPE : DEEP DRONE, CONTACT # 8 & 9, P & T
ALL          POSSIBLE AFT FUSELAGE SIDEWALL                                                03/10/86 JOE KILGORE, RI LSS
ALL          NO ET IDENTIFIED                                                              03/10/86 W. FEAGAN, MMC
ALL          NO SPARTAN HALLEY VISIBLE                                                     03/10/86 DEAN ZIMMERMAN

** TAPE NUMBER   : 085

* SOURCE OF TAPE : JSL DIVE #1265, TAPE J7, CONTACT #11 PINGER
010          CONTACT 11, THIS IS REPEAT OF SAME CONTACT - PINGER SET FOR  SRB              03/05/86 CHUCK NIGHSWONGER
             LOCATION PURPOSES
ALL          AFT SRB SEGMENT                                          SRB                  03/05/86 W. FEAGAN, MME LSS
ALL          FIND #301-1, 9' X 14' SRB CASE SEGMENT 43 PIN HOLES (APPROX) SRB              03/05/86 DENNIS CRAWFORD
             ON THE TANG END
ALL          NO ORBITER HARDWARE IDENTIFIED                                                03/05/86 JOE KILGORE, RI LSS
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                                                          UNDERWATER VIDEO LOG

POSITION    DESCRIPTION                                                     SYSTEM     TARGET    DATE      COMMENTS
                                                                                       NUMBER    TAPE         BY
                                                                                                 RECEIVED


** TAPE NUMBER    : 086

* SOURCE OF TAPE : CYLINDER/D1277, TAPE J8, CONTACT #301-1
ALL         AFT SRB SEGMENT                                                 SRB                  03/10/86 W. FEAGAN, MME LSS
ALL         SECTION OF SRM CASE SEGMENT APPEARS TO HAVE STRESS RELIEF.      SRB                  03/10/86 KEITH COATES
            FLAP ON TANG END.  CONTAINS SOME PROPELLANT (UP TO 3 INCH
            THICKNESS)
ALL         ONE SIDE APPEARS TO BE SYSTEMS TUNNEL AREA WITH STRAIGHT        SRB                  03/10/86 KEITH COATES
            LINE CUT PRODUCED BY RANGE DESTRUCT SYSTEM.  APPROXIMATELY
            43 TANG HOLES (86 ARC SECTION.
ALL         HAS FIELD JOINT - APPEARS TO HAVE OUTER LEG OF CLEVIS BROKEN SRB                     03/10/86 KEITH COATES
            OFF ON END.  PART IS 14 FT LONG, 9-10 FT WIDTH.  NO POSITIVE
            ID AS TO RH OR LH.
ALL         BASED ON PREDICTED BURNBACK PATTERN PART APPEARS TO BE FROM  SRB                     03/10/86 KEITH COATES
            FWD SEGMENT CYL
ALL         NO TDRSS ID                                                                          03/10/86 CHESTER HAMER
ALL         NO SPARTAN HALLEY VISABLE                                                            03/10/86 DEAN ZIMMERMAN
ALL         NO ORBITER HARDWARE IDENTIFIED                                                       03/10/86 JOE KILGORE, RI LSS

** TAPE NUMBER    : 087

* SOURCE OF TAPE : DEEP DRONE, FIX, DIVE #39-41, CONTACT 23-214
ALL         NO ET IDENTIFIED                                                                     03/08/86 W. FEAGAN, MME LSS
ALL         SUSPECT SRB DEBRIS, VIDEO NOT CLEAR, SUSPECT PIECE IS 4'        SRB                  03/08/86 MACK PHILLIPS
            HIGH BY 6' LONG
ALL         NO ORBITER HARDWARE IDENTIFIED                                                       03/08/86 JOE KILGORE, RI LSS

** TAPE NUMBER    : 088

* SOURCE OF TAPE : DEEP DRONE, P&T, DIVE #39-41, CONTACT # 23 & 214
ALL         NO ET IDENTIFIED                                                                     03/08/86 W. FEAGAN, MME LSS
ALL         SAME AS TAPE 87 BUT CLEAR- NOT SRB                                                   03/08/86 DENNIS CRAWFORD
ALL         NO ORBITER HARDWARE IDENTIFIED                                                       03/08/86 JOE KILGORE, RI LSS

** TAPE NUMBER    : 089

* SOURCE OF TAPE : JSL II, DIVE 1279, CASE SEGMENT, SRB INHIBITOR
ALL         AFT SRB SEGMENT                                                 SRB                  03/11/86 W. FEAGAN, MME LSS
ALL         NO ORBITER HARDWARE IDENTIFIED                                                       03/11/86 JOE KILGORE, RI LSS
ALL         NO TDRS                                                                              03/11/86 R. G. LABROAD, SPACECOM

** TAPE NUMBER    : 090

* SOURCE OF TAPE : JSL II, J-10-1, DIVE #1281, CONTACT #195, CYLINDER CASE
ALL         AFT SRB SEGMENT                                                 SRB                  03/12/86 W. FEAGAN, MME LSS
ALL         NO ORBITER HARDWARE IDENTIFIED                                                       03/12/86 JOE KILGORE, RI LSS
ALL         NO TDRS                                                                              03/12/86 R. G. LABROAD, SPACECOM
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UNDERWATER VIDEO LOG

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 091					
* SOURCE OF TAPE : JSL II, J-10-2, DIVE 1281, CONTACT #195, CYLINDER CASE					
ALL	AFT SRB SEGMENT	SRB		03/12/86	W. FEAGAN, MME LSS
ALL	NO ORBITER HARDWARE IDENTIFIED			03/12/86	JOE KILGORE, RI LSS
ALL	NO TDRS			03/12/86	R. G. LABROAD, SPACECOM
** TAPE NUMBER : 092					
* SOURCE OF TAPE : DEEP DRONE A, CONTACT #60				03/13/86	JOE KILGORE
0-50	NON SRB - LIGHTWEIGHT FLEXIBLE MATERIAL			03/13/86	M. PHILLIPS, MTI
ALL	NO ORBITER PARTS IDENTIFIED			03/13/86	JOE KILGORE
** TAPE NUMBER : 093					
* SOURCE OF TAPE : DEEP DRONE B, CONTACT #60					
500	APPEARS TO BE ET HYDROGEN TANK BARREL SECTION OR SECTIONS	ET		03/13/86	W. FEAGAN
ALL	NO ORBITER PARTS IDENTIFIED			03/13/86	JOE KILGORE
** TAPE NUMBER : 094					
* SOURCE OF TAPE : DEEP DRONE FIX, CONTACT #181 & 185					
010	DRUM			03/12/86	M. PHILLIPS, MTI
150	NON SRB, FLEXIBLE MATERIAL (MOVES WITH CURRENT) POSSIBLE ET			03/12/86	M. PHILLIPS, MTI
ALL	NO ORBITER PARTS IDENTIFIED			03/12/86	JOE KILGORE
** TAPE NUMBER : 095					
* SOURCE OF TAPE : DEEP DRONE P&T, CONTACT 181 & 185					
1325	POTENTIAL SRB			03/12/86	M. PHILLIPS, MTI
320	COULD POSSIBLY BE ET	ET		03/12/86	W. FEAGAN
ALL	DEEP DRONE P&T, CONTACT #181 & 185			03/12/86	JOE KILGORE
** TAPE NUMBER : 096					
* SOURCE OF TAPE : DEEP DRONE FIX, CONTACT #191					
ALL	NO IDENTIFIABLE ORBITER			03/13/86	J. KILGORE
ALL	NO IDENTIFIABLE ORBITER			03/13/86	J. H. KILGORE
** TAPE NUMBER : 097					
* SOURCE OF TAPE : DEEP DRONE FIX, CONTACT #191					
3600	POSSIBLE PORTION OF MIDBODY FRAME WITH 2 PARTIAL BORON STRUTS			03/13/86	J KILGORE
975	ET HYDROGEN TANK BARREL SECTION	ET		03/13/86	W. FEAGAN

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                                              UNDERWATER VIDEO LOG
                                                                            SYSTEM     TARGET   DATE     COMMENTS
POSITION      DESCRIPTION                                                              NUMBER   TAPE        BY
                                                                                                RECEIVED

** TAPE NUMBER    : 098

* SOURCE OF TAPE : NR-1, TAPE #14                                                               03/10/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/10/86 J. H. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/10/86 R. G. LABROAD, SPACECOM
ALL           NO TDRS

** TAPE NUMBER    : 099

* SOURCE OF TAPE : GEMINI DIVE 21, CONTACT #262-224-225-264                                     03/11/86 W. FEAGAN, MMC LSS
ALL           GEMINI - NOT ET                                                                   03/11/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/11/86 J. H. KILGORE
ALL           NO IDENIFIABLE ORBITER

** TAPE NUMBER    : 100

* SOURCE OF TAPE : DEEP DRONE FIX, CONTACT #192                                                 03/16/86 W. FEAGAN, MMC LSS
ALL           APPEARS TO BE EMPTY TAPE.                                                         03/16/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/16/86 J. H. KILGORE
ALL           NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 101

* SOURCE OF TAPE : DEEP DRONE P&T, CONTACT #192                                                 03/16/86 W. FEAGAN, MMC LSS
ALL           APPEARS TO BE OLD DEBRIS                                                          03/16/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/16/86 J. H. KILGORE
ALL           NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 102

* SOURCE OF TAPE : DEEP DRONE FIX, CONTACT #339, DIVE #57                                       03/18/86
                                                                                                03/18/86 DENNIS CRAWFORD
0-1255        APPEARS TO BE AN OLD ROCKET AFT SECTION WITH 2 TAIL FINS
              PROTRUDING FROM THE SIDE.  CYLINDER DIA APPROX 5 FT.
              (PERSHING ROCKET?)                                                                03/18/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/18/86 W. FEAGAN, MMC
ALL           NO ET IDENTIFIED                                                                  03/18/86 J. H. KILGORE
ALL           NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 103

* SOURCE OF TAPE : DEEP DRONE P&T, CONTACT #339, DIVE #57                                       03/18/86
                                                                                                03/18/86 DENNIS CRAWFORD
ALL           SAME AS TAPE 102.  AFT END OF SPENT ROCKET MOTOR.  HIGH
              CONCENTRATION OF MARINE GROWTH.  MAYBE A PERSHING ROCKET                          03/18/86 J. KILGORE
ALL           NO IDENTIFIABLE ORBITER                                                           03/18/86 W. FEAGAN, MMC
ALL           NO ET IDENTIFIED                                                                  03/18/86 J. H. KILGORE
ALL           NO IDENTIFIABLE ORBITER
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                                      UNDERWATER VIDEO LOG

POSITION    DESCRIPTION                                              SYSTEM    TARGET    DATE      COMMENTS
                                                                               NUMBER    TAPE        BY
                                                                                       RECEIVED

** TAPE NUMBER    : 104

* SOURCE OF TAPE : JSL II DIVE 1287, CONTACT #538                                       03/19/86 J. KILGORE
ALL         NO IDENTIFIABLE ORBITER                                  SRB                03/19/86 W. FEAGAN, MMC
ALL         NO ET IDENTIFIED                                         SRB                03/19/86 J. H. KILGORE
ALL         NO IDENTIFIABLE ORBITER                                  SRB                03/19/86 R. G. LABROAD, SPACECOM
ALL         NO TDRS

** TAPE NUMBER    : 105

* SOURCE OF TAPE : DEEP DRONE P&T, TGT 325 & 215                                        03/18/86 DENNIS CRAWFORD
0001        SRB CYLINDER SEGMENT APPROX 90 DEGREE ARC.  NO OUTER LEG OF  SRB
            CLEVIS SEEN, ONLY INNER LEG REMAINS.  NO TANG.                              03/18/86 DENNIS CRAWFORD
4463        ANCHOR                                                                      03/18/86 J. KILGORE
ALL         NO IDENTIFIABLE ORBITER                                                     03/18/86 W. FEAGAN, MMC
ALL         NO ET IDENTIFIED                                                            03/18/86 J. H. KILGORE
ALL         NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 106

* SOURCE OF TAPE : DEEP DRONE FIX TGT 325 & 215                                         03/18/86 L. JENSEN, MTI
0           POSSIBLE SRM - VIDEO RESOLUTION NOT CLEAR ENOUGH TO IDENTIFY SRB            03/18/86 L. JENSEN, MTI
460-1600    PROBABLE SRM - FACTORY JOINT CLEVIS WITH OUTER LEG GONE      SRB            03/18/86 J. KILGORE
ALL         NO IDENTIFIABLE ORBITER                                                     03/18/86 W. FEAGAN, MMC
ALL         NO ET IDENTIFIED                                                            03/18/86 J. H. KILGORE
ALL         NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 107

* SOURCE OF TAPE : JSL II, TAPE J12, CONTACT #502, DIVE 1288                              /  /   DENNIS CRAWFORD
            SRB SEGMENT, APPROX 90 DEGREE.  SEGMENT RIPPED AT LEAK   SRB
            CHECKPORT ON TANG ZERO DEGREES.  LSC CUT AT 90 DEGREE.  NO
            SIGN OF CLEVIS AT THE OTHER END

* SOURCE OF TAPE : JSL II TAPE J12, CONTACT #502, DIVE 1288                             03/20/86 W. FEAGAN, MMC
ALL         NO ET IDENTIFIED                                                            03/20/86 R. G. LABROAD, SPACECOM
ALL         NO TDRS                                                                     03/20/86 DENNIS CRAWFORD
ALL         SRB SEGMENT APPROX 90 DEGREE.  SEGMENT RIPPED AT LEAK CHECK  SRB
            PORT ON TANG ZERO DEGREES.  LSC CUT AT 90 DEGREE.  NO SIGN
            OF CLEVIS AT OTHER END.                                                     03/20/86 JOE KILGORE
ALL         NO IDENTIFIABLE ORBITER

** TAPE NUMBER    : 108

* SOURCE OF TAPE : JSL II DIVE 1287, CONTACT 538, J11                                   03/19/86 DEAN ZIMMERMAN
0-END       NO SPARTAN HALLEY                                                           03/19/86 L. JENSEN, MTI
ALL         FWD SKIRT - PARACHUTES                                   SRB                03/19/86 JOE KILGORE
ALL         NO IDENTIFIABLE ORBITER
```

UNDERWATER VIDEO LOG

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 109					
* SOURCE OF TAPE : JSL II DIVE 1289. TGT 497. J12					
O-END	NO SPARTAN HALLEY			03/24/86	DEAN ZIMMERMAN
001	RIGHT FRUSTRUM SEPARATION MOTORS WITH FRUSTRUM SKIN	SRB		03/24/86	DENNIS CRAWFORD. MTI
ALL	NO IDENTIFIABLE ORBITER			03/24/86	JOE KILGORE
ALL	FWD BOOSTER SEPARATION MOTORS & STRUCTURAL BOX	SRB		03/24/86	K. COATES
** TAPE NUMBER : 110					
* SOURCE OF TAPE : JSL II DIVE 1289. TGT 497. J13					
O-END	NO SPARTAN HALLEY			03/24/86	DEAN ZIMMERMAN
001	RIGHT SRB SNUB RING WITH PARACHUTE LINES ATTACHED	SRB		03/24/86	DENNIS CRAWFORD. MTI
ALL	NO IDENTIFIABLE ORBITER			03/24/86	JOE KILGORE
** TAPE NUMBER : 111					
* SOURCE OF TAPE : DEEP DRONE FIX. DIVE #74. CONTACT 324					
ALL	POOR QUALITY VIDEO. NO DISCERNIBLE HARDWARE			03/29/86	CHRIS POULSEN. NASA
** TAPE NUMBER : 112					
* SOURCE OF TAPE : DEEP DRONE P&T. DIVE #74. CONTACT 324					
ALL	IMAGE NOT CLEAR. UNIDENTIFIED OBJECT			03/29/86	CHRIS POULSEN. NASA
** TAPE NUMBER : 114					
* SOURCE OF TAPE : JSL2 DIVE #1294. TARGET 615-2					
ALL	SRM DEBRIS. FIELD JOINT CUT AT THE SYS TUNNEL. MOST OF CLEVIS OUTER LEG REMOVED. TRACES OF VACUUM PUTTY ON JOINT. NO TANG. 2-3 INCHES OF PROPELLANT IN VARIOUS LOCATIONS ON SEGMENT	SRB	615	03/30/86	DENNIS CRAWFORD
** TAPE NUMBER : 115					
* SOURCE OF TAPE : JSL1 DIVE 1274. TARGET 503-1					
ALL	FWD DOME WITH IGNITER. 619 FEET DEPTH	SRB	503	03/27/86	DENNIS CRAWFORD
** TAPE NUMBER : 116					
* SOURCE OF TAPE : JSL1 DIVE 1724. TARGET 504-1 AND 504-2					
ALL	TARGET 504-1 AFT SKIRT OUTER DIA WITH SOME OF PART NUMBER VISIBLE ????-0125-002 - TARGET 504-2 APPEARS TO BE AFT SKIRT CLEVIS JOINT	SRB	504	03/27/86	DENNIS CRAWFORD
** TAPE NUMBER : 117					
* SOURCE OF TAPE : JSL I. J16 DTV 98. ODC 412 & 413 & 474					
150	STEEL BAR VERTICALLY IMPALED ON THE OCEAN FLOOR. TOO MUCH MARINE GROWTH AND RUST TO BE SHUTTLE MATERIAL			03/31/86	DENNIS CRAWFORD

POSITION	DESCRIPTION	SYSTEM	TARGET NUMBER	DATE TAPE RECEIVED	COMMENTS BY
** TAPE NUMBER : 118					
* SOURCE OF TAPE : JSL I, DIVE 1278, OTV 99, OOC 517					
ALL	AFT NOZZLE CARBON WRAP. COMPLETE 360 BY APPROX 36" HIGH	SRB		03/31/86	DENNIS CRAWFORD
** TAPE NUMBER : 119					
* SOURCE OF TAPE : JSL I DIVE #1731, TARGET #579					
ALL	SRM ETA SEGMENT. APPROX 3' OF CLEVIS. NO VISIBLE REMAINS OF CLEVIS OUTER LEG. INHIBITOR ABOUT 12' HIGH. 1 1/2 TO 2" PROPELLANT UNIFORMALLY DECREASING TO ABOUT 1 INCH AT TANG END	SRB		04/03/86	DENNIS CRAWFORD, MTI
ALL	BOTH ETA STUBS IN PLACE. HOLES ON THE STUBS ARE ECCENTRIC AND SIGNS OF SOOT IN STAB AREA. PIECE OF ET TRANSITION STILL ATTACHED TO STUB	SRB		04/03/86	DENNIS CRAWFORD, MTI
** TAPE NUMBER : 121					
* SOURCE OF TAPE : JSL I, DIVE #1730, CONTACT #21 (1 OF 2)					
0-130	SRB AFT SEGMENT CASE PART TARGET ADDENDUM #XI	SRB		04/02/86	KEITH COATES, MSFC
130	ADDENDUM X (21-5) TARGET	SRB		04/02/86	KEITH COATES, MSFC
250	ADDENDUM XVI	SRB		04/02/86	KEITH COATES, MSFC
** TAPE NUMBER : 122					
* SOURCE OF TAPE : JSL I, DIVE #1730, CONTACT #21 (2 OF 2)					
		SRB		04/02/86	KEITH COATES, MSFC
0-215	INSTALLATION OF SNAP SHACKLES ON 21-9, ADDENDUM XVI	SRB		04/02/86	KEITH COATES, MSFC
215	TARGET 21-5, ATTEMTP TO INSTALL THREADED SHACKLES	SRB		04/02/86	KEITH COATES, MSFC
360	TARGET 21-2, ADDENDUM II	SRB		04/02/86	KEITH COATES, MSFC
440	SMALL PIECE, UNKNOWN	SRB		04/02/86	KEITH COATES, MSFC
** TAPE NUMBER : 126					
* SOURCE OF TAPE : NR-1, TAPE 14B					
001-550	SRM DEBRIS, CLEVIS FIELD JOINT WITH 6" OF INHIBITOR IN PLACE ABOUT 8' OF JOINT VISIBLE OUT OF OCEAN BOTTOM. OUTER LEG OF CLEVIS IS BROKEN OFF. NO PROTUSIONS. LOC. 28 43.68N, 79 3	SRB		04/07/86	DENNIS CRAWFORD, MTI
1112	RIGHT ETA SEGMENT	ET		03/31/86	DENNIS CRAWFORD, MTI
2430	SRM DEBRIS CLEVIS ABOUT 50" CIRCUMFERENCE, 8' OD, 458 FT FEPTH	SRB		03/31/86	DENNIS CRAWFORD, MTI
550-660	DOME WITH IGNITER	SRB		04/07/86	DENNIS CRAWFORD, MTI
830	DIA 14' NOZZLE RING (PHENOLIC)	SRB		03/31/86	DENNIS CRAWFORD, MTI
** TAPE NUMBER : 127					
* SOURCE OF TAPE : NR-1, TAPE 15					
0-800	8' X 10' PIECE OF SRM CASE FRAGMENT - POSSIBLE CLEVIS END	SRB		04/07/86	KEITH COATES, MSFC
1325	LARGE PIECE OF SRB CASE	SRB		04/07/86	KEITH COATES, MSFC
2400	LARGE PIECE (180 DEGREE, PLUS) OF CASE	SRB		04/07/86	KEITH COATES, MSFC
3150	LARGE PIECE OF SRB CASE	SRB		04/07/86	KEITH COATES, MSFC

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04/14/86
                                                  UNDERWATER VIDEO LOG
POSITION    DESCRIPTION
                                                                  SYSTEM     TARGET   DATE       COMMENTS
                                                                             NUMBER   TAPE         BY
                                                                                      RECEIVED

4250        SRM CASE JOINT                                        SRB                 04/07/86 KEITH COATES, MSFC
4800        UNKNOWN PIECE OF METAL STRUCTURE                      SRB                 04/07/86 KEITH COATES, MSFC
4950        TRIANGULAR SHAPED PIECE OF UNKNOWN ORIGIN. SMALL      SRB                 04/07/86 KEITH COATES, MSFC
4904        UNKNOWN ORIGIN METAL. MIGHT BE SRM                    SRB                 04/07/86 KEITH COATES, MSFC
5150        RING. MAYBE ET ATTACH                                 SRB                 04/07/86 KEITH COATES, MSFC
5400        CLEVIS END OF SRM CASE                                SRB                 04/07/86 KEITH COATES, MSFC

** TAPE NUMBER   : 120

* SOURCE OF TAPE : NR-1, TAPE 16
0-440       PROPELLANT FIELD                                      SRB                 04/07/86 KEITH COATES, MSFC
1430        SRM SKIN WITH PROPELLANT. NR-1 OBSERVER GUESSED 2 1/2' X 1'  SRB          04/07/86 KEITH COATES, MSFC
1690        6' X 12' SRM CASE FRAGMENT TANG                       SRB                 04/07/86 KEITH COATES, MSFC
2371        TARPAULIN                                                                 04/07/86 KEITH COATES, MSFC
440         6' X 4' SRM CASE FRAGMENT. 28-30 TANG HOLES           SRB                 04/07/86 KEITH COATES, MSFC


** TAPE NUMBER   : 133

* SOURCE OF TAPE : NR-1, TAPE #17
0-30        SMALL PIECES #TGT 433
1150        RUDDER FROM SHIP
1263        SRM CASE FRAGMENT 8' X 10' TANG & CLEVIS END          SRB                 04/08/86 KEITH COATES, MSFC
1740        SRM CASE FRAGMENT, RING - 160 ARC - CLEVIS END - 6"-8"  SRB               04/08/86 KEITH COATES, MSFC
            HEIGHT                                                SRB                 04/08/86 KEITH COATES, MSFC
2036        CANNOT IDENTIFY BY TAPE. SHIP OBSERVER ON BOARD SAYS PIECE  SRB           04/08/86 KEITH COATES, MSFC
            LOOKS OLD AND NOT SHUTTLE.  CORAL GROWTH
2127        NON SRM                                                                   
2200        NON SRM                                               SRB                 04/08/86 KEITH COATES, MSFC
200         SRM CASE FRAGMENT, 4' X 3'                            SRB                 04/08/86 KEITH COATES, MSFC
30          SMALL PIECES OF NOZZLE/CASE SCATTERED ALONG NORTHERLY SRB                 04/08/86 KEITH COATES, MSFC
            DIRECTION FROM #24                                    SRB                 04/08/86 KEITH COATES, MSFC
524         NEW HYDRAZINE BOTTLE
767         SRM CASE FRAGMENT, HAS PROPELLANT, SMALL PIECE 2 1/2' X 2   SRB           04/08/86 KEITH COATES, MSFC
            1/2'                                                  SRB                 04/08/86 KEITH COATES, MSFC

** TAPE NUMBER   : 134

* SOURCE OF TAPE : JSL II, DIVE #1308, OOC #631, J22
ALL         CASE SKIN W/PROPELLANT, APPEARS TO HAVE CLEVIS AT BOTH ENDS, SRB          04/11/86 KEITH COATES, MSFC
            NO BURN MARKS OR SCORCH MARKS NOTED, ATTACHED SHACKLE FOR
            RETRIEVAL AND PINGER, ONE END HAS O-RING GROOVES
```

APPENDIX E
List of Recovery Video Tapes

As part of the Search, Recovery and Reconstruction Team effort, a library of Underwater Recovery Video Tapes was maintained. Recovery videos were copied and provided to JSC, MSFC, the Supervisor of Salvage, USN. The master video tape was kept in the data viewing area, Room 2174, Headquarters Building, KSC.

A Team number plus the debris description was entered into a personal computer data base system. This Appendix E is a list of all Recovery Video Tapes logged into the data base as of close of business, April 10, 1986.

Recovery video tapes were taken during recovery operations. Views are largely of interest to salvage operations and tend to document possible methods for rigging the item for retrieval.

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Page No.      1
04/10/86
                                    LOG OF UNDERWATER RETRIVAL

POSITION    DESCRIPTION                                              SYSTEM    TARGET   TAPE      REFERENCE
                                                                               NUMBER   DATE      ORIGINAL
                                                                                                    TAPE
                                                                                                   NUMBER

** TAPE NUMBER    :R   1

* SOURCE OF TAPE : GEMINI. DIVE #14. RECOVERY OF OOC CONTACT #26-2
ALL         RETRIEVAL                                                                   03/10/86

** TAPE NUMBER    :R   2

* SOURCE OF TAPE : GEMINI DIVE #14 & 15 RECOVERY OOC CONTACT #26-1
ALL         RETRIEVAL                                                                   03/10/86

** TAPE NUMBER    :R   3

* SOURCE OF TAPE : GEMINI DIVE #17 & 18. CONTACT #218-219-220
ALL         OCEAN BOTTOM AND FISH                                                       03/10/86

** TAPE NUMBER    :R   4

* SOURCE OF TAPE : STENA WK/HORSE REC OF LH SRB - GEMINI
ALL         RETRIEVAL                                                SRB                03/07/86

** TAPE NUMBER    :R   5

* SOURCE OF TAPE : GEMINI SUB & STENA WKHORSE REEL 3 TARGET 11
ALL         RETRIEVAL                                                                   03/06/86

** TAPE NUMBER    :R   6

* SOURCE OF TAPE : GEMINI - TAPE 4. TO #11. ATTACHING TOOL TO SRB
                                                                     SRB                03/07/86

** TAPE NUMBER    :R   7

* SOURCE OF TAPE : GEMINI DIVE #36. TARGETS B-C-D-E-F-G
O           SMALL PIECE OF AFT SKIRT                                 SRB                03/27/86

** TAPE NUMBER    :R   8

* SOURCE OF TAPE : GEMINI DIVE 36. CONTACT 21-9
ALL         SAME AS TAPE R7 EXCEPT ADDITIONAL CONTACT 21-9 LARGE PIECE  SRB              /  /
            OF SRM CONTAINING TANG AND CLEVIS ONLY ONE STIFFENER STUB
            VISIBLE. RECOVERY PLAN ADDENDUM XVI

** TAPE NUMBER    :R   9

* SOURCE OF TAPE : GEMINI. TARGET 292
ALL                                                                                     03/16/86
** TAPE NUMBER    :R  10

* SOURCE OF TAPE : GEMINI RECOVERY. CONTACT 301
ALL         RECOVERY                                                                    03/19/86
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51-L
LAUNCH READINESS REVIEW

JANUARY 14, 1986

STS 51-L RANGE SUPPORT

ESMC · WSMC · AFFTC · KMR · PMTC · USAEPG · WSMR
DOD SHUTTLE NETWORK

CAPT WALTER E. FRED
PROGRAM SUPPORT MANAGER
ESMC/ROPN

SPACE
TRANSPORTATION
SYSTEM
LEAD RANGE

STS 51-L LAUNCH READINESS REVIEW

MAJOR CHANGES IN SUPPORT REQUIREMENTS

CAPT W. FRED
ESMC/ROPN

JANUARY 1986

- Launch
  - Launch Pad 39B
- On-Orbit
  - ARIA coverage of TDRS-B IUS burn
- Landing
  - EOM landing at KSC

SPACE TRANSPORTATION SYSTEM LEAD RANGE	STS 51-L LAUNCH READINESS REVIEW RANGE SAFETY ASSESSMENT	CAPT W. FRED ESMC/ROPN JANUARY 1986

- Final flight plan approval (17 Dec 85)
- Range Safety displays (20 Jan 86)
- RSO training complete (17 Jan 86)
- Range Safety mission rules (1 Feb 84)

SPACE
TRANSPORTATION
SYSTEM
LEAD RANGE

STS 51-L LAUNCH READINESS REVIEW

LEAD RANGE STATUS

CAPT W. FRED
ESMC/ROPN

JANUARY 1986

	Ready to support
ETR	X
AFFTC	X
WTR	X
WSMR	X
USAEPG	X
KMR	X
PMTC	X
COAST GUARD	X
4950 TW	X

LAUNCH READINESS REVIEW

DEPARTMENT OF DEFENSE MANAGER'S SUPPORT

DOD LANDING SUPPORT

Site	Role	Status
Edwards AFB, CA	AOA/Alt EOM/ELS	Ready
White Sands Space Harbor, NM	Alt AOA/ELS	Ready
Hickam AFB, HI	ELS	Ready
Andersen AFB, Guam	ELS	Ready
NSA Souda Bay, Greece	ELS	Ready
NAF Diego Garcia, Indian Ocean	ELS	Ready
Moron AB, Spain	ELS	Ready

DOD MISSION SUPPORT

	Status
• Contingency	
– MEDEVAC (KSC)	Ready
– Military airlift	Ready
– Military sealift	Ready
– Search and rescue	Ready
– Harvest Bare	Ready
• Other	
– DOD communications	Ready
– DOD TACAN's	Ready
– Support Operations Center (SOC)	Ready

DOD READINESS CERTIFICATION

The DOD is ready to support STS 51-L program requirements.

John N Shults

John N. Shults
Colonel, USAF
Director, DOD Manager's
Space Transportation System
Contingency Support Office

MISION 51-L SHUTTLE MISHAP
SURFACE SEARCH
May 8, 1986

Approved by:

John N. Shults
Colonel, USAF
Director, DOD Manager's STS
Contingency Support Office

Charles F. Henschel
Landing Recovery Director
NASA, KSC

Enclosure 1

Landing Recovery Director Pre-Launch Responsibilities

For all STS launches, the Landing Recovery Director (LRD) assumes an active role starting at T-3 hours in the Shuttle Countdown. The following timeline delineates the actions taken by the LRD prior to the launch or STS 51-L:

28 January 1986

T-3 Hours	Communications checks completed between the JSC Flight Director and the NASA Convoy Commander (NCC). (NCC located at the KSC Shuttle Landing Facility in the event of a Return to Launch Site Abort—RTLS.)
T-2 Hours	Completed communications checks with: 1. JSC Landing Support Officer (LSO) 2. Ground Operations Manager (GOM), Edwards Air Force Base 3. White Sands Airfield Support Coordinator 4. Dakar Ground Manager (DGM), Transatlantic Abort Site (TAL) 5. CCAFS SOC Director (DOD), the Emergency Response Team 6. Booster Recovery Director (BRD)
T-2:00	Booster Recovery Director reported heavy seas. (Note: BRD had earlier received permission to leave recovery area because of extremely heavy seas.)
T-1:55	Verified with Cape Leader (DOD) the readiness of the rescue helicopter.
T-1:20	NASA Convoy Commander reported readiness to support if required.
T-30 Min.	Verified RTLS, TAL and AOA sites ready to support if required.
T-20 Min.	Verified the RTLS runway number and passed this information on to the NCC. The LRD reported to the LSO that landing sites were ready for launch.
T-12 Min.	Verified the Cape Leader (DOD) had the contingency support operations ready for launch and emergency aircraft and personnel were on station.
T-9 Min. Hold	During the 10-minute built in hold at T-9 minutes, the LRD verified to the NASA Test Director that he was ready to resume the count and was "go for launch."

From T-9 minutes through liftoff and up to the point of the accident, the LRD reported on OIS Channel 135, Landing Field Prime 1, Landing Field Prime 2, and the Convoy Commander Net, the significant events as they were occurring and giving the T-times at intervals to keep informed the personnel listed in this report.

Post-incident timelines are included in the "Initial Response to STS 51-L Mishap."

Procedures Used by Landing Recovery Director and Landing Forces

1. S0007—Shuttle Countdown
2. S0026—Shuttle Landing—Post Landing Convoy Operations—EAFB
3. S0027—Shuttle Landing—Post Landing Convoy Operations—WSSH
4. S0028—Shuttle Landing—Post Landing Convoy Operations—KCS
5. S0029—Shuttle Landing—Post Landing Convoy Operations—CLS
6. S0039—Shuttle Landing—Post Landing Convoy Operations—TAL/CLS Dakar, Senegal
7. S9907—Non-continental United States Contingency Landing Site Emergency Procedures Document
8. S9914—Orbiter Flight Crew Emergency Egress and Escape During Landing Phase at EAFB.
9. S9915—Orbiter Flight Crew Emergency Egress and Escape During Landing Phase at KSC.
10. S9924—Orbiter Flight Crew Emergency Egress and Escape During Landing Phase as WSSH

Initial Response to STS 51-L Mishap

The following is a chronology of the actions taken and events logged by the Department of Defense Manager for Space Transportation System Contingency Support Operations (DDMS), Support Operations Center (SOC), Booster Recovery Forces, and the Landing Recovery Director (LRD) following the structural breakup of STS 51-L at 1139 hours Eastern Standard Time (EST) on January 28, 1986, until termination of the surface search effort on February 7, 1986.

28 January 1986

1140 EST	Personnel on board the SRB recovery ships did not observe the structural breakup due to cloud cover in their area. The Liberty Star and Freedom Star were notified by the LRD via the Booster Recovery Director (BRD) of the accident and were given the approximate latitude and longtitude of the impact area. The two ships proceeded immediately at best speed (15 knots) toward the impact point. The recovery ships picked up several pieces of debris while en route to the impact area. The first H-3 helicopter (call sign Jolly 1) was notified to take off and hold short of the safety zone established for falling debris.
1141 EST	Aircraft and ship search and rescue support was requested by the SOC using the search and rescue telephone network (SARTEL).
1142 EST	The National Military Command Center (NMCC) was notified by the SOC of the mishap and a continuous dialog was established.
1146 EST	The SOC requested Range Safety Office (RSO) provide an estimated time of when the debris impact area would be clear to allow rescue forces to enter. Estimate was 55 minutes. Periodic updates were requested.
1150 EST	Jolly 1 reported sighting debris falling and impacting the ocean surface.
1210 EST	An HC-130 aircraft and two HH-3 helicopters departed the Clearwater Coast Guard Station for the mishap area.
1214 EST	The Joints Chiefs of Staff (JCS) formed a Shuttle Response Cell. A briefing was provided by SOC personnel.
1230 EST	The second H-3 (Jolly 2) reported being airborne and proceeding to the area.
1231 EST	The JCS Shuttle Response Cell was provided an update by SOC personnel.
1237 EST	The RSO cleared SAR aircraft (three fixed wing, three helicopters) into the safety zone. Aircraft reported sighting debris even before entering the area.
1250 EST	All Department of Defense (DOD) forces not supporting the SAR activities were released.
1259 EST	The SOC provided an update of the current situation for the Chief of Staff, Air Force.

1311 EST Miami Rescue Coordination Center was assigned responsibility of SAR mission coordinator for the SAR operations by Coast Guard COMLANTAREA. They requested the Eastern Space and Missile Center Aircraft Control Officer (ESMC/ACO) control SAR aircraft in the area for them.

1315 EST The SRB Marine Operations Manager (MOM) had laid out the search pattern and directed the vessels in conducting the search. Hard contacts were identified via sonar on the bottom and their positions plotted. Both Liberty Star and Freedom Star launched their Avons to recover floating debris while the sonar search continued.

1356 EST Three Coast Guard cutters (CGC) reported en route to the area.

1400 EST Initial debris handling procedures were established. Explosive Ordinance Disposal (EOD) personnel were placed on standby.

1624 EST The NASA Landing Recovery Director (LRD) requested DDMS to initiate a major SAR effort when it became apparent that local resources would not be adequate.

1650 EST DDMS alerted the Navy Supervisor of salvage and requested a representative deploy to Cape Canaveral AFS.

1715 EST SAR aircrews were debriefed. Copies of logs, charts, and written statements were provided to NASA/EX-NAMO.

1730 EST BRD contacted Perry Offshore regarding availability of the Remotely Operating Vehicle (ROV), SPRINT. The BRD also contacted SONAT in Houston, Texas to obtain the services of the ROV, SCORPIO. MOM directed Freedom Star to continue the search and Liberty Star to proceed to port.

1800 EST Twelve aircraft from Air Force, Navy, and Coast Guard were participating in the search. In addition, ten Navy, NASA and Coast Guard ships were in the search area.

2030 EST Liberty Star and Freedom Star arrived in port to off-load retrieved debris.

2100 EST ROM directed by KSC Deputy Center Director to call up whatever support necessary for mobilization.

29 January 1986

The search and recovery efforts continued.

The USS Dauntless was the On-Scene Commander (OSC) until the arrival of the USS Dallas, who assumed command.

The LRD requested the Supervisor of Salvage personnel provide a preliminary briefing for NASA on their proposed plan of action.

Members of the interim investigation team were appointed.

Debris found on the beach was transported to Hangar F at Cape Canaveral and checked by EOD.

ESMC requested augmentation for their EOD teams. DDMS tasked Eglin AFB to provide an eight-man EOD team. The team deployed via aircraft to assist in the salvage effort. The Eglin EOD team arrived at Patrick at 1800 EST.

DDMS requested assistance from the Foreign Technology Division (FTD), Wright Patterson AFB, OH, in determining their video tape analysis and enhancement capability.

30 January 1986

Rear Admiral Cueroni (CC 7CG District) met with DDMS and NASA to coordinate Coast Guard support for the continuing search and recovery. Later in the day, NASA requested Supervisor of Salvage to conduct a subsurface salvage operation.

OSC CGC Dallas recovered a large piece of fuselage which was brought into the dock.

31 January 1986

The Navy started planning for subsurface salvage operations.

The Coast Guard continued recovering floating debris.

DDMS coordinated a request from NASA for Harvest Bare aircraft hangars to store debris.

The recovery liaison group was formed.

1 February 1986

DDMS coordinated with CINCLANT OPCONCEN for use of USS Guam to pick up an SRB frustum discovered floating off the Georgia coast. ESMC EOD and two Navy EOD personnel from NS Mayport were deployed to the ship via helicopter.

At 0900 EST the Harvest Bare hangars arrived via two C-141's.

NASA requested two metallurgist/safety specialists from Ft. Rucker, AL.

The USS Guam recovered an SRB frustum.

The Liberty Star deployed with side scan sonar provided by the Supervisor of Salvage

Metallurgist/safety specialist arrived at KSC from Fort Rucker.

2 February 1986

A Marine CH-46 helicopter airlifted the SRB frustum from the USS Guam to CCAFS. The EOD personnel were recovered and redeployed.

The first underwater photography of debris identified a portion of the Inertial Upper Stage (IUS).

3 February 1986

CGC Cape Upright recovered Orbital Maneuvering Subsystem (OMS) helium tank off Charleston, SC coast. DDMS advised Cape Upright of hazards and sent handling instructions.

OMS propellant tank was found by NASA SRB recovery ship.

NASA determined the priority of items to be located/recovered as follows:

1. Right-hand SRB
2. Left-hand SRB
3. Orbiter Crew Compartment
4. Payload

4 February 1986

Liberty Star made sonar contact with what was believed to be the right SRB. The Independence moved to the contact made by the Liberty Star and attempted to photograph same. Freedom Star worked close in targets and used the ROV Recon IV to photograph contacts.

Tug Venture out of Mayport reported an orange cylinder with white stripes 67 miles east/northeast of Ponce Inlet.

The USS Preserver retrieved a conical-shaped object 5.5 feet at base, 2.5 feet high, with stainless steel cone tip at 31°10'N 80°25'W.

The SOC requested that the Coast Guard search a 30 NM circle centered at 29°00'N 80°10.5'W. The USCGC Dallas searched the 30 NM circle and did not find anything.

Numerous scallop boats reported finding STS debris in nets. An EOD representative was sent to monitor catches.

Set up of the Harvest Bare hangars was completed.

5 February 1986

Ship and aircraft activities resulted in the following findings: The USCGC Bear found three pieces of light metal at 31°48'N 079°25'W; USCGC Tampa found a piece of burned styrofoam and a piece of cloth at 33°27'N 076°26'W; Freedom Star and Landing Craft Utility (LCU) made strong sonar contacts at 28°39'N 080°16'W; and Inertial Upper Stage (IUS) propellant and four small parts were brought in by two scallop boats.

The Coast Guard sent a Notice to Mariners declaring the search area a safety area which suspended all fishing operations in the area.

The Freedom Star returned to port for 24 hours and had side scan sonar installed. Liberty Star worked area 28°49'N 079°03'W moving toward the west. Independence stood by to identify contacts located by Liberty Star.

Due to the dwindling amount of floating debris, the Coast Guard requested termination of the major surface search effort after 7 February. DDMS recommended termination of the major surface search to Mr. Crippen and received his concurrence.

6 February 1986

No significant findings were reported. The Freedom Star and Liberty Star searched an area ½-mile wide (east and west) by 10 miles long (north and south) centered on longitude 80°16'44"W between latitude 28°33'N and 28°43'N. The Independence in port waiting for installation of the ROV Deep Drone.

The USS Preserver divers and EOD divers received Shuttle orientation briefing. NASA and SPC engineers were put on board to identify items to be recovered.

7 February 1986

DDMS relayed NASA's request that all military ships and aircraft operating off the coast between Jacksonville, FL, and Cape Hatteras, NC, be on the lookout and report Shuttle debris.

The USCGC Tampa directed five fishing boats out of the safety/security area. Several small Shuttle items were recovered from the fishing boats.

Major surface search effort was terminated.

RESOURCES USED IN SAR EFFORTS

	Ships			*Aircraft*		
Date	*Coast Guard*	*Navy*	*NASA*	*Coast Guard*	*Navy*	*Air Force*
28 Jan	4	4	2	4	4	4
29 Jan	4	5	2	3	1	4
30 Jan	4	5	2	3	1	4
31 Jan	4	5	2	2	4	2
1 Feb	4	4	2	5	4	2
2 Feb	4	4	2	5	4	2
3 Feb	7	4	3	6	3	2
4 Feb	4	0	3	5	1	0
5 Feb	5	0	3	3	1	2
6 Feb	3	0	3	4	1	1
7 Feb	3	0	3	3	1	0

Documentation used in DDMS, Booster Recovery Force, and LRD Operations:

STS Flight Program Requirements Directive, Volume 1
DOD Manager's STS Contingency Support Operations Plan
DOD SOC Checklist and Log
Shuttle Transportation System Salvage Plan, KVT-PL-0021
US Coast Guard Situation Reports

RCA MTP RADAR SYSTEMS ANALYSIS

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PRO-5317
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Radar Data Analysis and Impact Estimation for STS 51-L Debris

1.0 *INTRODUCTION*

This report summarizes and evaluates radar data collected after the mishap of the Challenger launch vehicle during the STS 51-L launch on 28 January 1986. The primary purposes of the evaluation were to provide impact locations for debris recovery and, when possible, to identify the tracked objects.

All times in this report are expressed in seconds relative to 1638:00 Zulu, unless otherwise specified.

This report does not encompass the evaluations associated with impact locations based upon data of ESMC optical tracking systems or the AN/FPS-66 radar operated by FAA, nor the detailed analyses or radar signal "signature" data. Radar sites are listed in Table 3.

2.0 *SUMMARY*

Estimated impact locations for nine objects are listed in Table 1 and mapped in Figure 1. Eleven objects had been tentatively identified from the radar track spans depicted in Figures 2A and 2B, but Objects E and J were found to be redundant to Objects G and F, respectively.

Impact A was of prime importance since it represented debris from the starboard SRB. Objects F and G were parachutes which are believed to have been recovered from the ocean's surface. Objects D and B were believed to be relatively sizeable (2-5 meters) and dense, as gauged by radar boresight recordings and the early impact times of T+207 and T+319 seconds, respectively. Similarly, an impact time of T+212 seconds suggested that Object K was a relatively dense object, but its radar cross-section was less than 0.1 square meters.

Objects I and C each had a moderately small final descent rate of about 134 feet/second, with Object C having a very distinctive radar signature with cross-section speculars as large as 158 square meters. Object H was of little interest for recovery operations, since it appeared to be small, light object which may very well have floated upon impact.

In attempting to acquire debris, several aircraft were inadvertently tracked after T+1030 seconds, and there were several instances in which radars locked up on spurious signals. These irrelevant track spans are indicated by asterisks in Figures 2A and 2B.

3.0 *EVALUATION PROCEDURES*

Radar raw metric data, boresight video recordings, event records, and analog recordings become available on Janaury 31. A catalog of tracked objects was begun and, concurrently, priority was given to estimating impact locations for the starboard SRB and other sizeable objects.

In the interest of timeliness, the initial estimate of impact location for each object was based on the final valid radar measurement, which was selected by inspection and then transformed to latitude and longitude. This procedure was more accurate, of course, for objects which had been tracked nearly to splash.

Impact estimates were refined as RAPP processed data became available. Among other outputs, the RAPP computer program provided full density radar data transformed to geodetic latitude, longitude, and height. In utilizing these data, the altitude of each object was extrapolated graphically or numerically to splash to obtain estimated impact time. Latitude and longitude were then extrapolated to impact time to obtain impact position.

Radar boresight video recordings were used to identify visible objects to the extent possible and to estimate physical sizes. Radar cross-section and signature characteristics were evaluated from radar digital recordings and analog Signal/Noise (S/N) recordings.

Identification of radar data spans relative to the tracked object was facilitated by computer plots of the target ground tracks. Radar data were correlated with tracking-camera data by transforming the radar data to the optics sites.

4.0 *DISCUSSION*

The objects listed in Table 1 are discussed individually in the following paragraphs.

4.1 *Object A (Starboard SRB)*

Following structural breakup at T+73 seconds, Radar 1.17 shifted track to the starboard SRB without operator assistance. The exhaust plume of the SRB was visible on the radar boresight TV video until approximately T+113 seconds. At T+88 seconds, and again at T+91 seconds, the aspect of the SRB was such that two distinct plumes were discernible.

After Range Safety destruct at T+110 seconds, Radar 1.17 continued track of a large SRB piece until LOS near impact at T+286 seconds. Based on signature analysis of the radar S/N recordings, it was estimated that the tracked object was a cylinder/cone combination having an overall length of 5.3 meters. Impact was approximately 39 nautical miles east and 12 nautical miles north of Pad 39B.

In addition to Radar 1.17, the starboard SRB also was tracked by the Ponce de Leon IGOR until T+282.9 seconds. A comparison of metric data, carried out by transforming 1.17 data to the IGOR location, confirmed that the two instruments tracked the same object. The IGOR video tape showed that Range Safety destruct action caused at least 3 large fragments, plus smaller pieces, to separate from the tracked object.

Radar/IGOR data for the starboard SRB are summarized in Table 2.

4.2 *Object B*

Target B was a smoking object which was tracked by Radars 1.17, 1.16, and 0.14, with all three radars being on track at impact at about T+391 seconds. Radar 1.16 provided the most extensive coverage, which commenced at T+137 seconds at an altitude of 48 K feet. The physical extent of the object was estimated from radar boresight recordings to be 2 to 3 meters, and the average radar cross-section was 0.5 to 2.0 square meters.

Impact position, which was estimated from Radar 0.14 data, was only about 4,000 feet from the Object D impact.

4.3 *Object C*

Object C was acquired by Radar 1.17 at an altitude of 25 K feet and was tracked down to an altitude of about 700 feet. Estimated impact time was T+543 seconds at a location approximately 26 nautical miles east and 3 nautical miles north of the launch pad.

Object C was not visible on the Radar 1.17 boresight recordings, which appeared to be affected by glare.

The Radar 1.17 S/N recording showed a distinctive pattern with a period of 3.5 to 4.0 seconds, in which radar cross-section spikes as large 158 square meters arose from a baseline level of about 0.4 square meters. The target appeared quite complex, and may have consisted of a flat plate of about 1.5 feet extent with accompanying tubes or struts.

4.4 *Object D*

Object D was acquired by Radars 19.17 and 0.14 at T+85 and T+107 seconds, respectively, and was tracked to LOS by each radar. It was also tracked briefly by Radar 3.13 from T+128 to T+153 seconds. Impact occurred at T+207 seconds at a location approximately 18 nautical miles east and 1 nautical mile north of Pad 39B.

The object was visible on the Radar 0.14 boresight TV recording from acquisition to horizon. It left no trail and had a bright white appearance (black and white recording) until about T+175 seconds. The image then showed flashes of both white and black until T+187 seconds, after which time it was consistently black. The physical extent of the object was estimated from the TV recording to be about 5 meters.

Object D was visible on the wider-angle boresight recording of Radar 19.17 only intermittently. At least six plumes or smoke trails appeared in the field of view up to T+150 seconds, indicating that other objects may have impacted in the vicinity of Object D.

Radar S/N recordings showed Object D to have an average radar cross-section of 1.3 to 3.2 square meters. The radar signature was relatively devoid of distinctive speculars or nulls.

4.5 *Object F*

Object F was identified from radar boresight recordings to be a parachute of approximately 45 feet diameter. Total height of the parachute and suspended object was estimated to be 95 feet.

Object F was tracked at various times by Radars 1.17, 19.17, and 0.14. Initial acquisition was by Radar 19.17 at T+349 seconds at an altitude of 50.2 K feet. Average radar cross-section was 2.0 to 10.0 square meters.

Impact location was estimated using data from Radars 1.17 and 0.14, which were tracking near the impact time of T + 888 seconds. Impact was approximately 31 nautical miles east and 1 nautical mile north of Pad 39B. Final descent rate of the parachutes was 70 feet/seconds.

4.6 *Object G*

Target G was tracked at various times by all five mainland radars and Radar 3.13. It was identified from radar boresight video to be a chute or chutes having a diameter of about 110 feet. The suspended object or objects had a physical extent of about 40 feet and appeared to include a smaller, or partially opened, chute. The total height of the chute and suspended objects was about 210 feet. Average radar cross-section was 3 to 10 square meters.

The most extensive coverage of Object G was by Radar 1.16, which acquired an altitude of 66.5 K feet and had continuous track to near impact at T+1487 seconds. The impact location, approximately 37 nautical miles east and 1 nautical mile south of Pad 39B, was estimated from the Radar 1.6 track data. Final descent rate of the chute was about 37 feet/second.

4.7 *Object H*

Object H was a slow falling target which was tracked by Radars 0.14 and 19.14, and briefly by Radar 19.17. First acquisition was by Radar 0.14 at an altitude of 24 K feet, and final coverage was by Radar 19.14 at an altitude of 4 K feet.

Because the object fell at a rate of only 20 feet/second, it was necessary to extrapolate Radar 19.14 data ahead 223 seconds to splash, which diluted the accuracy of the estimated impact location. The slow descent rate suggested a low density object which might have floated upon impact. Approximate impact time was T+2583 seconds at a point 56 nautical miles east and 7 nautical miles south of Pad 39B.

The radar cross-section of Object H was .02 to .13 square meter.

4.8 *Object I*

Based upon Radar 3.13 data for T+388 to T+457 seconds, the Object I impact was estimated to be approximately 34 nautical miles east and 5 nautical miles north of the launch pad. The uncertainty of the Table 1 impact estimated was judged to be 1 minute, since the radar data were extrapolated for the rather large time of 277 seconds from an altitude of 37 K feet.

Radar cross-section was .02 to 50 square meters, and final descent rate was 134 feet/second.

4.9 *Object K*

Radar 19.14 tracked target K from T+185 to T+200 seconds, but the data appeared reasonable only for the time space of T+190 to T+197 seconds. Radar elevation angle data were essentially static prior to T+190 seconds and were erratic after T+197 seconds. There was some doubt that any of the data represented valid track since radar S/N remained rather constant at 38 to 45 dB, even when the radar pedestal was apparently pointed several beamwidths off the target. There was a distinct possibility that the returned energy was from a cloud, smoke column, or distributed reflectors, rather than a single discrete target. However, there also remained the possibility that a discrete object was discriminated from the background signal level and was tracked for seven seconds.

During the time span of T+190 to T+197 seconds, the apparent target descended from 18.3 K feet to 12.5 K feet altitude, giving a projected impact time of 212 seconds at a point only 1 K feet from the estimated Object D impact. This seemed reasonable, since it appeared from Radar 19.17 boresight recordings that several objects had been falling near Object D.

The indicated radar cross-section during the entire track was .003 to .06 square meter.

TABLE 1 IMPACT ESTIMATES FROM RADAR DATA

Obj		Impact Parameters				
ID	T+Sec	N. Lat	W. Long	CEP*	Radar	Comments
A	286	28°49'10"	79°52'29"	2.5"	1.17	Starboard SRB
B	319	28°38'23"	80°16'58"	1.0"	0.14	Smoking Object
C	543	28°40'12"	80°07'28"	1.0"	1.17	Not Visible
D	207	28°39'01"	80°16'44"	1.0"	19.17	5-meter Size
F	888	28°38'54"	80°02'11"	2.0"	0.14	Small Chute
G	1487	28°36'01"	79°55'00"	1.0"	1.16	Large Chute
H	2583	28°30'16"	79°33'35"	50.0"	19.14	Not Visible
I	730	28°42'59"	79°59'08"	60.0"	3.13	Not Visible
K	212	28°38'58"	80°16'33"	4.0"	19.14	Not Visible

* Circular Error Probability

TABLE 2

STARBOARD SOLID ROCKET BOOSTER
DATA SUMMARY FOR OBJECT "A"

Radar 1.17 Data at Significant Times

T+Sec	Event	Height (K ft)
73.2	Mishap	50.8
110.3	Destruct	101.3
113.0	Break-up	104.0
146.3	Apogee	122.4
286.0	Impact	0.0

Radar 1.17 Signature Data

Cylindrical Portion Peak:	27.6 dBsm (575 m²)
Conical Portion Peak:	28.9 dBsm (776 m²)
Cylindrical Portion Length:	2.4 meters
Conical Portion Length:	2.9 meters

Ponce de Leon Mobile IGOR

Tracked same object as Radar 1.17 to T+282.9 seconds; displayed 3 additional pieces separating after T+113 seconds.

TABLE 3 GEODETIC COORDINATES FOR ESMC C-BAND RADARS

Designation	Location	WGS-72 Survey		
		+ N. Latitude	+ E Longitude	Geodetic Height Meters
19.17	KSC	28°37'33.2213"	279°19'01.3468"	- 19.31
1.17	CCAFS	28°31'43.2797"	279°24'34.6546"	- 23.63
1.16	CCAFS	28°28'53.6479"	279°25'24.0130"	- 15.81
19.14	KSC	28°25'28.7859"	279°20'07.6130"	- 18.53
0.14	PAFB	28°13'34.8742"	279°24'02.0120"	- 14.94
3.13	GBI	26°36'56.0369"	281°39'07.3290"	- 15.30

NOTE: Survey values refer to the center of rotation of the antenna

IMPACTS FROM RADAR DATA

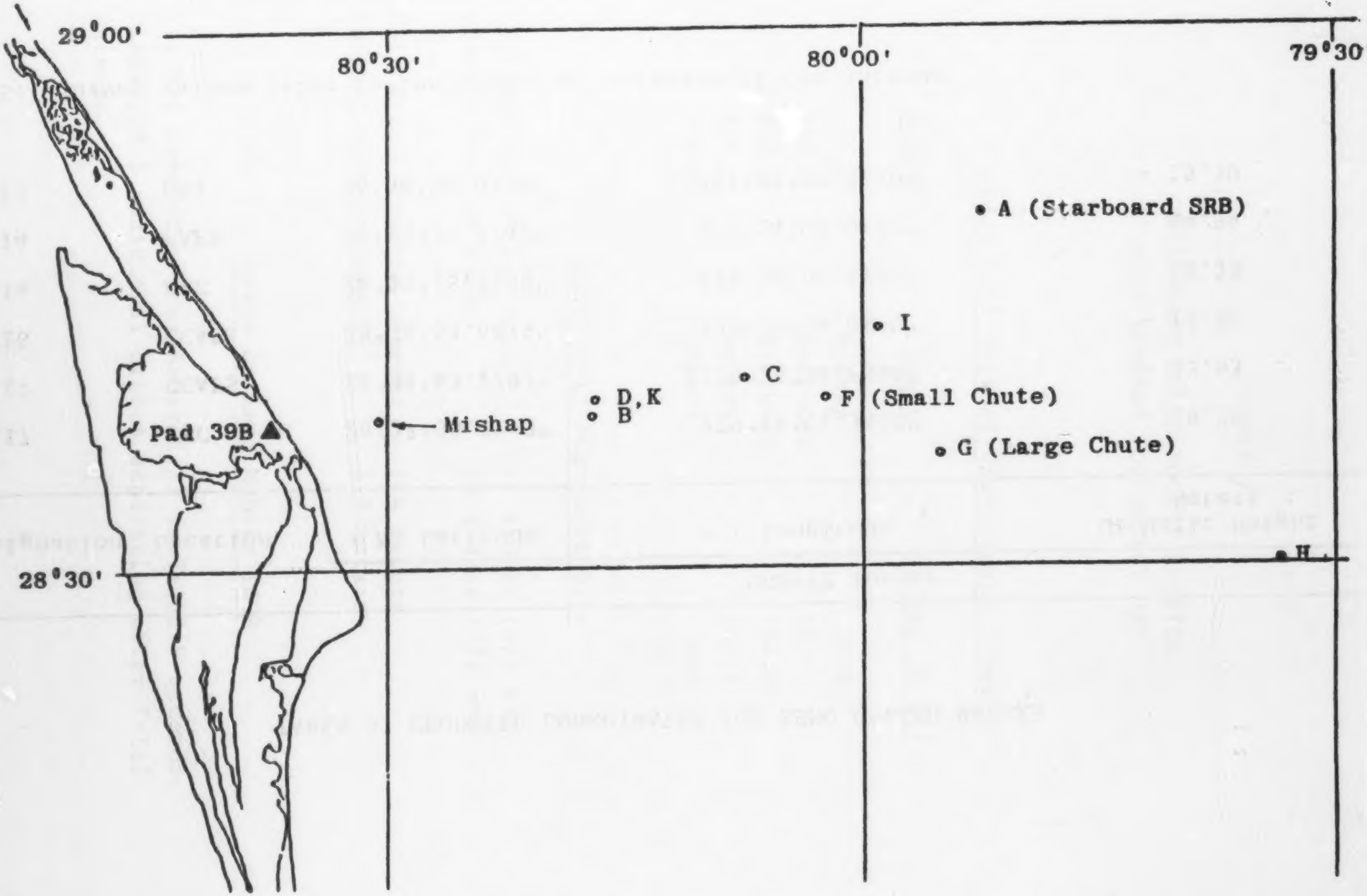
29°00'
80°30'
80°00'
79°30'
28°30'
A (Starboard SRB)
I
C
D,K
B
F (Small Chute)
G (Large Chute)
Mishap
Pad 39B
H

Figure 1

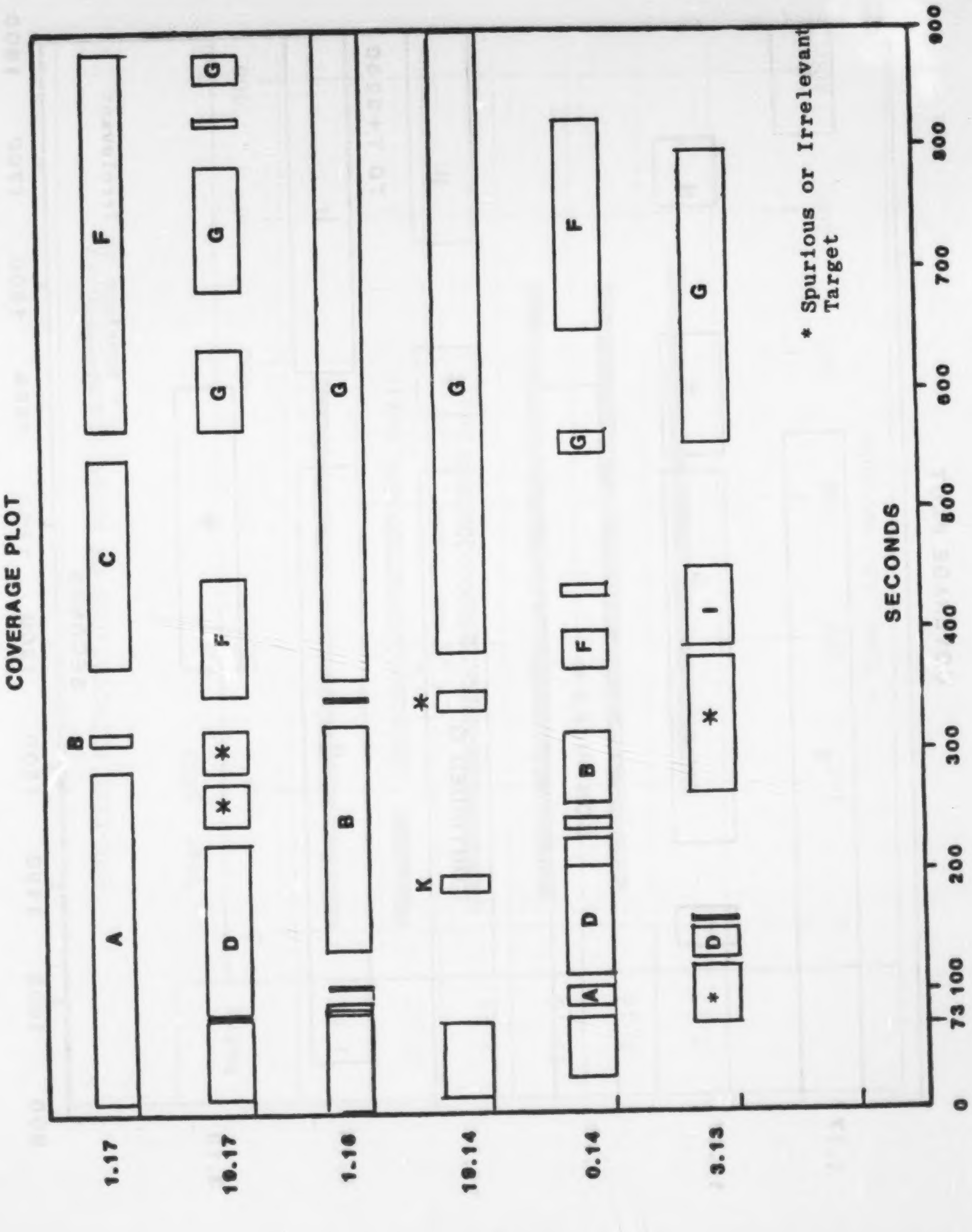
COVERAGE PLOT
1.17
10.17
1.16
10.14
0.14
3.13
A
B
C
F
D
*
*
F
G
G
G
G
B
G
K
*
G
A
D
B
F
G
F
*
D
*
I
G
* Spurious or Irrelevant Target
SECONDS
0
73
100
200
300
400
500
600
700
800
900

Figure 2A

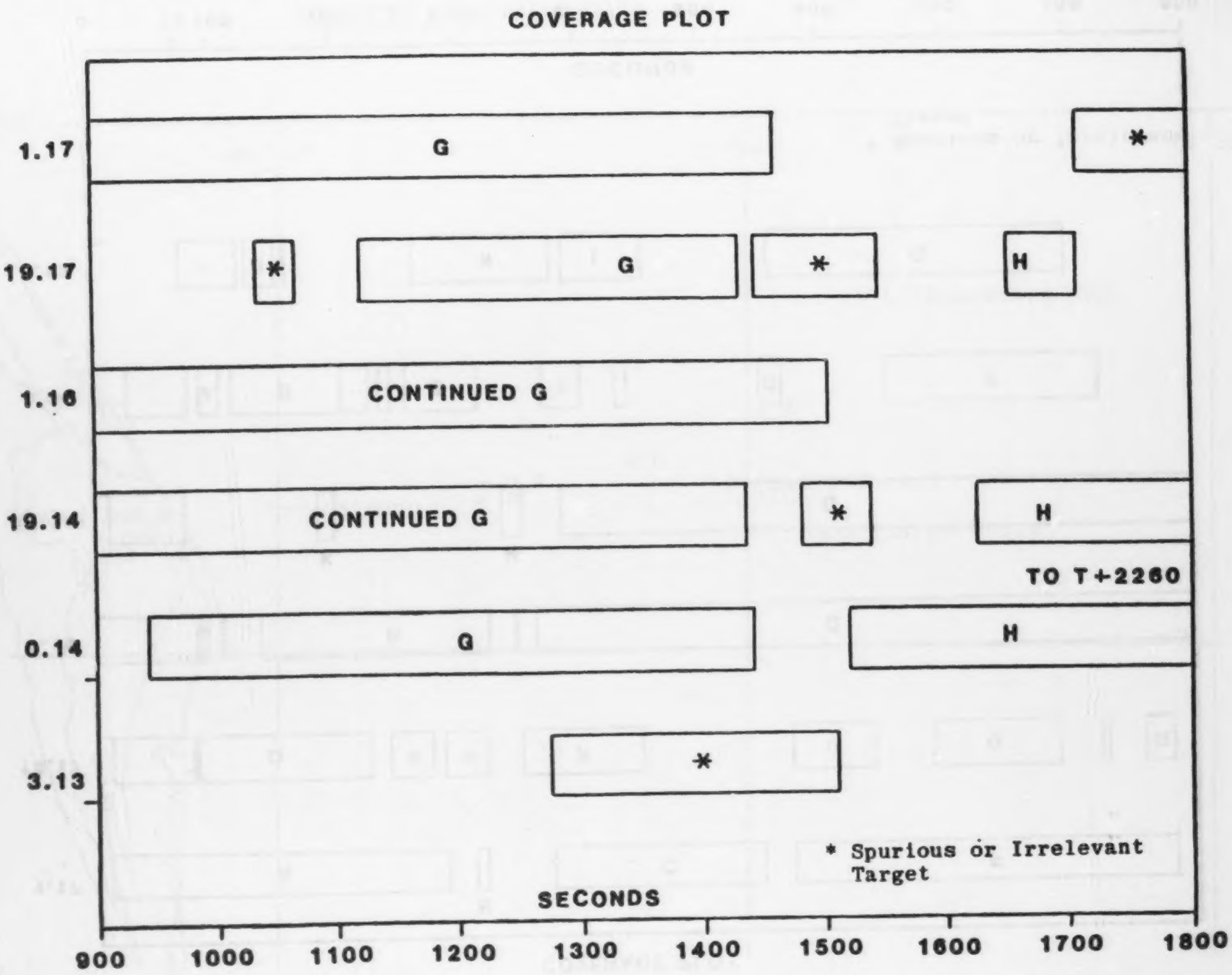
COVERAGE PLOT
1.17
19.17
1.16
19.14
0.14
3.13
G
*
*
G
*
H
CONTINUED G
CONTINUED G
*
H
TO T+2260
G
H
*
* Spurious or Irrelevant Target
SECONDS
900
1000
1100
1200
1300
1400
1500
1600
1700
1800

Figure 2B

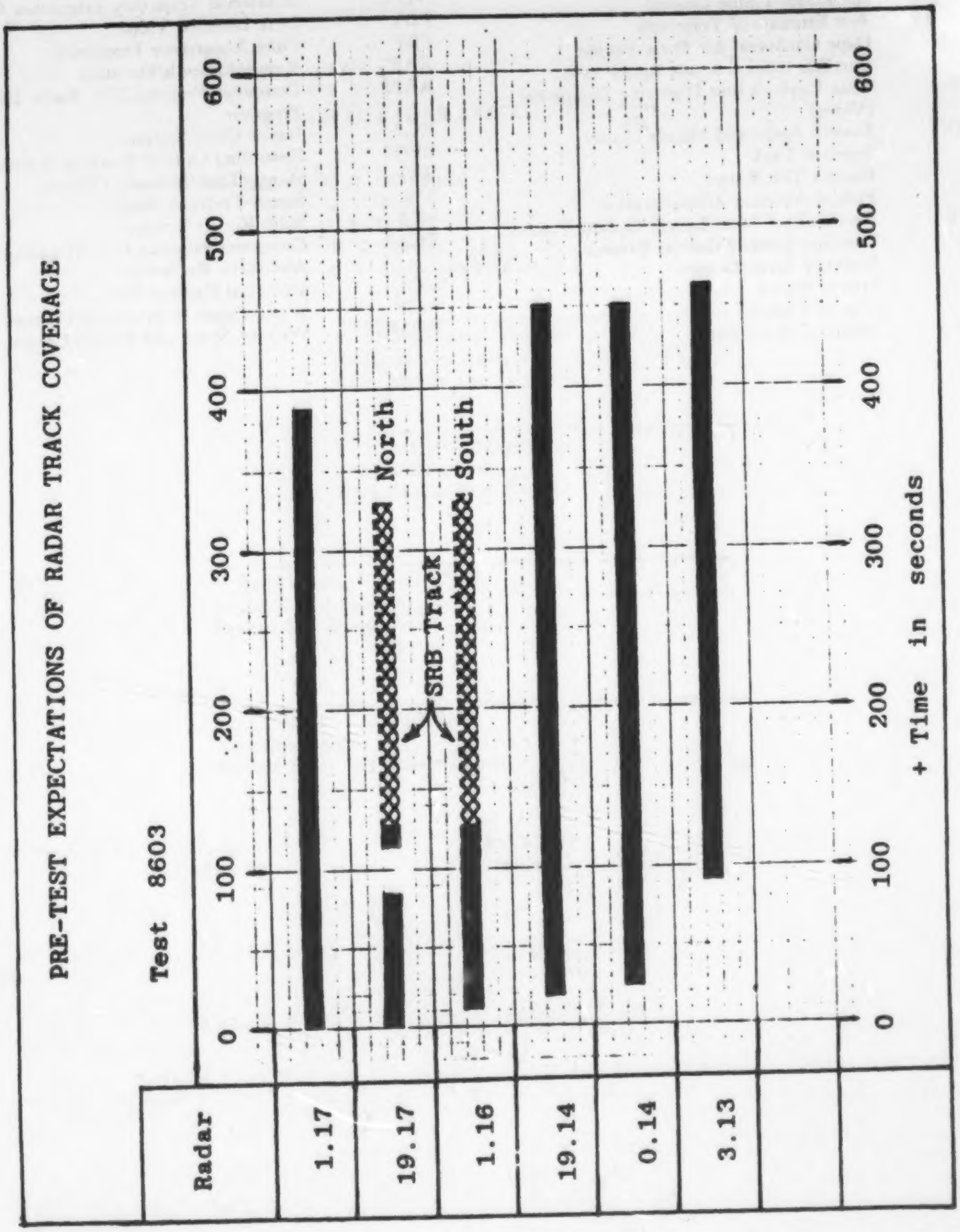
PRE-TEST EXPECTATIONS OF RADAR TRACK COVERAGE
Test 8603
Radar
1.17
19.17
1.16
19.14
0.14
3.13
North
South
SRB Track
0
100
200
300
400
500
600
+ Time in seconds

Figure 3

Glossary

AOS	Acquisition of Signal
ARTC	Air Route Traffic Control
BET	Best Estimate of Trajectory
CCAFS	Cape Canaveral Air Force Station
dBsm	DeciBels relative to one square meter
DPDE	Data Playback and Digitizing Equipment (Video)
ESMC	Eastern Space and Missile Center
ET	External Tank
ETR	Eastern Test Range
FAA	Federal Aviation Administration
IFLOT	Intermediate Focal Length Optical Tracker
IGOR	Intercept Ground Optical Recorder
KSC	Kennedy Space Center
LOS	Loss of Signal
LOV	Loss of Visibility
MCBR	Mobile C-Band Radar
MSFC	Marshall Space Flight Center
MIGOR	Mobile Intercept Ground Optical Recorder
NITE	N-Interval Trajectory Estimation Program
PDV	Peak Detected Video
PRF	Pulse Recurrence Frequency
RAE	Range/Azimuth/Elevation
RAPP	Computer Program 331, Radar Position Program
RCS	Radar Cross Section
ROTI	Recording Optical Tracking Instrument
RTI	Range/Time/Intensity (Video)
S/N	Signal-To-Noise Ratio
SRB	Solid Rocket Booster
TCAR	Computer Program 017, Tracking Camera Automatic Reduction
UCS	Universal Camera Site
WGS	World Geodetic System (ETR uses WGS-72)
WSMC	Western Space and Missile Center

RCA MTP RADAR SYSTEMS ANALYSIS

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STS 51-L Right SRB

1.0 *INTRODUCTION*

The STS 51-L Challenger disaster of 28 January 1986 was observed or measured by a number of sensors on the Eastern Test Range of ESMC. The STS 51-L Recovery Task Force has requested a report of all data evaluations pertinent to the Right Solid Rocket Booster (SRB), particularly those related to impact locations.

2.0 *SUMMARY*

The right SRB elements appeared in the observations of the Ponce de Leon MIGOR and UCS-15 IFLOT optical trackers, ETR Radars 1.17 and 0.14, and the FAA AN/FPS-66 Radar. Coverage by ETR radars and optical sites is depicted in Figure 1. Figure 2 is a map of sensors and impact locations, and Table 1 lists numerical values for impact locations and their estimated accuracies.

Impact Points R, RA, RC, and RD are confirmed elements of the right SRB. The altitude versus time profile for each of these objects is graphed in Figure 3. Impacts 2 through 7, representing targets detected by the FAA radar, are considered likely to be either right of left SRB elements, with the more Northerly impacts (2, 5, 6, 7) most likely being from the right SRB complex.

Report Section 3.0 which follows describes the right SRB data evaluations from ETR radars, ETR optical trackers, and the FAA radar. Section 4.0 describes the data processing for trajectory estimation and impact prediction. A reiteration of observations of the right SRB components is presented in summary fashion in Section 5.0.

3.0 *DATA EVALUATION*

3.1 ETR Tracking Radars

3.1.1 General

Two impact locations related to the right SRB were derived from ETR tracking radar data. One of these objects, Object R, was estimated to be a major piece of the SRB aft segment.

3.1.2 Object R

Following the structural breakup at T+73 seconds, Radar 1.17 shifted track to the right SRB which was positively identified by boresight video showing the anomalous plume. After Range Safety destruct at T+110 seconds, Radar 1.17 continued to track the largest SRB piece (predicted to be the Aft Segment and labeled Object R) until LOS near impact at T+286 seconds. Redundant track of the Right SRB by Radar 0.14 from T+89 to T+107 seconds was terminated by the Radar Controller, who directed Radar 0.14 to search for another object.

The altitude versus time profile for the Right SRB/Aft Segment is graphed in Figure 3. The altitude at destruct was about 102 K feet, and an apogee height of 123 K feet was reached at T+146 seconds.

The S/N recordings of Radars 1.17 and 0.14 during track of the intact SRB until T+110 seconds (Figure 4) showed peak Radar Cross Section (RCS) magnitudes up to 25 dBsm (decibels above a square meter), well below peak magnitudes observed later. These relatively small values were explained by the viewing geometry during the SRB's powered flight, which precluded broadside aspects and presented returns from the aft skirt and nozzle. During the track from T+110 to T+170 seconds, Radar 1.17 S/N recordings displayed periodic level variations typical of a tumbling object but did not show the specular returns which would be expected for broadside illumination of the SRB's cylindrical or conical surfaces.

The Radar 1.17 S/N recordings after T+170 seconds (Figure 5) displayed repetitive sequences which were typical of near-broadside returns from both a cylindrical shape (symmetrical sidelobes) and a conical shape (asymmetrical sidelobes). The observed peak RCS magnitudes for each shape were compared with predicted values for various SRB segments (Tables 2), several of which were computed by Mr. M. Norton of RCA Data Processing. The peak RCS of the Object R cylinder was between 30.0 and 32.5 dBsm which, in relation to the SRB diameter of 12 feet, corresponded to a length between 7.0 and 9.4 feet. The peak RCS of the Object R conical portion was near 32.0 dBsm, which agreed closely with predicted values for the truncated cones of both the frustum (without nose cap) and aft skirt.

Conical plus cylindrical radar signature indicated that the tracked object was either the nose cone with attached forward skirt, or the aft skirt with a short section of SRB segment No. 1. Of these, the first was considered doubtful because of the absence of an orderly sidelobe structure which would be expected from the rather uniform surfaces; the second was believed to be more likely because the sidelobe irregularities could have resulted from surface components of the aft skirt or from the protruding nozzle.

Analysis of the ballistic characteristics of the metric trajectory (described later) predicted a weight of 73.5 K lbs for the tracked object. This further substantiates that the tracked object was a major portion of the aft segment. Underwater photographs of the debris field emanating from the predicted impact point positively confirmed this identification.

3.1.3 Object RD

Radar 0.14 tracked the right SRB from T+92 to T+106 seconds, and RTI (Range Time Intensity) displays processed at the DPDE facility from the recorded radar video output showed the presence of several separating pieces. Returns from these pieces ended when they left the antenna beam; i.e., at angular separations greater than 3 mils (approximately 550 feet) from the tracked object.

Figure 6a show returns from the SRB and seven separating pieces, displayed in a 45-km range window with fixed (constant range) window position. Figure 6b shows the same returns in an expanded 15-km window with the window start locked to the radar's range tracker. The "wiggles" in the Figure 6b traces are due to range tracker hunting as the separating pieces altered the centroid of the returns.

Metric range data were derived for Object RD, the separating piece visible until T+96 seconds in Figures 6a and 6b, by applying RTI range differentials to Radar 0.14 range-tracker data. The derived range measurements, displayed graphically in Figure 7, were utilized in a NITE BET computer run to estimate the impact location for Object RD.

Signal amplitude data for signature analysis were obtained by a playback track at the DPDE for the time span of T+93.6 to T+95.8 seconds. Figures 8a and 8b show signal amplitudes for the SRB and Object RD, respectively, from playback tracks. The signature of Object RD reveals a sequence of features (marked by arrows in Figure 8b) repeating at 0.8 second intervals, which suggests tumble or spin. These broad features may have originated from a small, fairly flat surface.

The peak RCS of Object RD was only .06 m^2 (− 12.6 dBsm) and average RCS was about .005 m^2 (− 23 dBsm). The values contrast with SRB values up to 5,000 m^2 (37 dBsm) during the same time span.

Unfortunately Radar 0.14 is the only Mainland ETR radar with receiver video recording capability. Consequently similar data on small pieces expelled from the SRB cannot be obtained from the other radar tracks.

3.2 ETR Optical Trackers

3.2.1 General

Optical tracking coverage, other than radar boresight video, of the right SRB was from the Ponce de Leon (PDL) MIGOR and UCS-15 IFLOT, was located as shown in Figure 1.

3.2.2 Discussion

All of the optical trackers, with exception of UCS-10 MIGOR and Melbourne Beach ROTI, were tasked to track the Orbiter/ET until LOV. UCS-10 was to track the north (right) SRB after separation and Melbourne Beach ROTI the south (left) SRB.

After the mishap at T+73 seconds, most camera operators searched for the Orbiter, tracking only briefly on pieces of debris.

Occasionally during their search, SRB's passed through the field of view. Where a track on an SRB did occur, it was only for a short period of time, not more than 10 seconds. Long periods of track were devoted to the parachutes.

Radar 1.17 and the PDL MIGOR tracked a common target to impact as confirmed by a comparison of the radar tracking data, transformed to the MIGOR Site, with the MIGOR data. Data throughout the track agreed to ±0.1 degree.

The right SRB could be readily identified because of its double plume. From the MIGOR tracking video, before command destruct, the double plume was prominently visible and provided the proof that the MIGOR was tracking the right SRB and therefore the 1.17 radar also tracked the right SRB. Film data were not available from the PDL MIGOR because of film breakage.

That part of the right SRB tracked by Radar 1.17 and PDL MIGOR was determined to be the aft section from radar signature data, weight estimates from the NITE computer program and underwater pictures.

The PDL video, at command destruct, showed that the SRB separated into a number of pieces. Three pieces, of near equal luminosity, remained in the field of view for several seconds. Two of the pieces, which have been designated Objects RA and RB, were continuously visible while in the field of view; but the third piece, Object RC, flashed on and off. Trajectories of these pieces, as seen in the video plane relative to the tracked aft section, are shown in Figure 9.

Another piece, flashing at approximately 2 flashes per second, appeared suddenly and remained in the field of view for nearly twenty seconds. It is shown in figure 10. The object's origin was tentatively identified as the aft segment of the right SRB but this could not be positively confirmed since it is visible only intermittently. Subsequent video image enhancement identified 2 more positions tieing the object back to the aft segment.

A review of available data, both film and video tapes, revealed that the UCS-15 IFLOT was the only other instrument tracking the right SRB at the time of destruct command. Figures 11 through 14 are UCS-15 photographs at 1 second intervals beginning at T+111.026 seconds. It can readily be seen that a large number of pieces came from the SRB. The four bright objects remaining, see Figure 14, have been correlated with the bright objects seen from PDL. Knowing the position of the aft section (brightest object in the photo) pointing angles could be computed to each of the objects from the measured in-plane offsets. This was accomplished for each picture frame (30 per second) while the objects were in the field of view. These data, in conjunction with the PDL data, were the basis for triangulations and trajectory generations. It is to be noted that the UCS-15 IFLOT is only an engineering sequential camera, i.e., having only timing recorded on the film and no mount orientation data. The mount orientation can only be determined if a target whose spatial coordinates are known is visible in the field of view. Fortunately, since the aft section was tracked by radar, its spatial position was known and orientation angles could be computed.

There are several smoking objects seen in the photos, one of which also seemed to be visible in the PDL video. Work is underway to read the offsets of all visible objects relative to the aft section on both the PDL video and UCS-15 film.

The video was read with a TV tracker at 10 samples per second. Each sample was read during still framing of the video. Objects which can just be seen dynamically (continous projection) fade into the background when viewed statically (single frame projection); thus, not all of the visible objects can be read with the present equipment. Possibly with the use of more sophisticated equipment, computer enhancements, etc., additional data might be forthcoming.

The shock wave from the Range Safety command destruct explosion was visible on the 16mm film from Camera E-705 installed on the UCS-15 mount. Measurements of the shock wave width versus time fit an inverted power curve as shown in Figure 15. Regression to zero width gives the explosion at time T+110.275 seconds. The propagation speed of the shock wave was on the order of 1000 m/s during the first few hundredths of a second with the expansion slowing to essentially zero within .1 second.

3.3 AN/FPS-66 Radar

3.3.1 General

The AN/FPS-66 radar is located at the southern extremity of Patrick AFB, on the west side of Route A1A, with a very favorable view for targets over the ocean. It scans at 5 revs/minute, detecting significant targets below 70,000 feet. The beam is 1.3° wide and the PRF is 360/second, so adequate targets yield about 15 successive returns on each beam passage. The radar is operated by FAA and the data are processed for map presentation by the FAA's Jacksonville ARTC Center of Hilliard, Florida. The maps of target detections were examined for corroboration of impact "R" (well-established by NITE processing of Radar 1.17), and then 6 more target impacts were found which appeared to be credible.

It must be remembered that no elevation or height data was measured, so slant range-to-ground range conversions could not be made. In the FAA data format, map granularity of one-third mile limited the plotting precision, but latitude/longitude values were also listed for improved accuracy.

3.3.2 Discussion

The target impacting at location R was well-documented from Radar 1.17 measurements of trajectory and radar cross section, and boresight television recordings. This same target was first detected by the FPS-66 at T+221 seconds, for which the altitude was known to be 50 K feet.

The target was observed at successive 12-second intervals through the known time of impact. These observations were classified as "long run length primary," indicating a well-confirmed or strong target return. After the known impact time, the FPS-66 continued to register hits downrange of the impact location which were of lesser confidence or "short run length primary" classification. These reflections were real, but must have been very light following debris or ashes that were not targets of substance.

The behavior just described for target manifestations in FPS-66 data were considered in the selection of significant targets from the remainder of the mapped detections. Re-entry appearance was assumed at about 50 to 70 K feet, and impact was reasoned to be about 5 observations (1 minute) later, with large targets meeting the criterion of "long run length primary."

The map regions under examination were those appropriate for an SRB target. (Since the SRB's had thrust for 38 seconds after the Orbiter structural breakup, the area of interest was further east than Orbiter/ET debris.) In this region the target density was not great, and discrete target traces could be more readily discerned.

The six target impacts shown in Table 1 were selected from the FAA data because each appeared to qualify by the "reasonableness" criteria applicable to known target "R".

However, except for proximity to "R", the six cannot be qualified as definitely portions of the right SRB, rather than the left SRB. Corroborative dáta from other trackers do not exist for these targets.

The data to Table 1 for targets 2 through 6 have been estimated somewhat coarsely regarding time of impact and the impact uncertainty ellipse. Since radar observations occurred at 12-second intervals with no altitude information, confidence in time values is about ± 12 seconds. The error ellipse shape and size reflects the observed dispersion of points on the original mapped data.

The great value of the FPS-66 radar has been its overall coverage of the accident scene, permitting some hits on all significant targets. The difficulty in using the data has been in the discrimination between significant targets and the multitude of small reflectors.

Feed back from the sonar search activities indicated returns at all but one of the impacts predicted from the FAA radar data. Due to the initial success and usefulness of these predictions, the

FAA radar data was thoroughly reanalyzed to see if additional probable tracks and impacts could be extracted. Eleven additional impact locations (having confidence estimates similar to the original figure 7) were extracted and are listed in Table 4.

The FAA data have been forwarded to specialists in the National Transportation Safety Boards in Washington, DC for further analysis for the Recovery Task Force.

4.0 *DATA PROCESSING*

4.1 General

Vehicle performance and impact prediction are normally routine and accurate computations are based upon extended tracking data from several radars or optical instruments. Only a very few of the STS 51-L pieces had long track spans or multiple instrument coverage. Impacts for those pieces were readily predicted with high accuracy. The challenge, however, was to provide useful impact accuracies for many objects which were observed for only a few seconds or did not have full "metric" data. The metric optical instruments on the range provided azimuth, elevation (and time) data on the tracked object. Position is computed by a triangulation process. Tracking offsets can be read post-test and used to correct the pedestal data in order improve trajectory accuracy. Accuracy can be further improved by using data from additional (redundant) trackers. For short periods of time after the initial structural breakup and after booster destruct, numerous non-tracked objects were visible in the film and TV recordings from the various optical sensors (metric optics, engineering sequential optics, and radar boresight video). Azimuth and elevation data from these objects can be computed by reading the angular offsets from the tracked object and suitably combining them with the pedestal metric data. If the object can be positively identified in data from two different camera sites, a triangulation can be performed to compute trajectory position. In the case of engineering sequential cameras only time data is recorded on the film and thus there is no azimuth or elevation data directly available for the optical axis. However, if there is some object visible in the frame for which full position data is available from any other source, the camera orientation can be computed and the data can be handled essentially the same as for the metric optics. In cases where there is only single camera coverage and triangulation is not possible a ballistic constraint can be used to estimate the trajectory. This approach becomes more accurate as the tracking span length increases.

The NITE program was used to perform these complex trajectory computations. It fits a set of redundant measurements best in a least-squares sense. The program permits user-definition of the gravitational and drag forces and the appropriate wind conditions. The trajectory fit also contrains the measurements to fit the equations of motion. The fitted data produced estimates of the drag parameter and the initial conditions of a position/velocity vector; then the equations of motion were numerically integrated to produce an impact point.

A measure of the accuracy of the impact location is provided by the parameters of the 95% confidence ellipse. The major and minor axes along with the azimuth of the major axis is given with the impact locations in Table 1.

Figure 2 illustrates the locations of the launch pad, instrumentation sites, and impact points. For Object R, the ground trace is provided from launch to impact.

Program NITE "N-Interval Trajectory Estimation," No.615, has been used at ESMC and WSMC for many years, and is a well known reference.

4.2 Object R

As stated in an earlier section, Radar 1.17 tracked the aft section to impact. However, the 1.17 RAE data were processed by computer program NITE to provide a "Best Estimate of Trajectory" including the impact location. This added confidence to the impact point already obtained from computer program RAPP. When meteorological data (including atmospheric density, wind speed, and direction) were used as part of the dynamics model, the NITE solution differed from the already obtained impact point by 59 feet. The NITE run also indicated the importance of using the wind data in NITE solutions involving other pieces.

Specifically, for the aft section, the impact point computed using wind data differed from the impact point computed without winds by approximately one-half mile. Figures 16 and 17 illustrate the wind speed and direction that were used.

Data from Radar 1.17 provided an initial estimate of the position and velocity vector. Marshall Space Flight Center (MSFC) provided information on the drag parameters for both a Tail-First descent and a Tumbling descent; see Figure 18. The NITE run using the drag for a Tail-First descent was judged to be slightly better than the run using tumbling descent drag for Plots of velocity and acceleration versus time are provided in Figures 19-26.

4.3 Objects RA, RB, and RC

The impact locations for these three pieces of the right SRB were computed using measurements from Ponce de Leon video recording and UCS-15 70mm and 16mm films. These pieces are referred to as RA, RB, and RC. Data time spans and data frequency are listed in Table 3.

For each of the three pieces the same procedure was used to process the data in order to obtain an estimated impact location.

Computer program TCAR (No. 017: Tracking Camera Automatic Reduction) was used (1) to transform the video and film readings to azimuth and elevation angles, and (2) to compute an initial estimate of the position vector at times when triangulation was possible. An estimate of the velocity vector at the beginning of a data span was computed manually by using difference techniques.

The azimuth and elevation data along with the position and velocity vector were then input into computer program NITE to obtain an impact point.

4.4 Object RD

A small amount of range data was obtained from RTI (Range Time Intensity) recordings. This range data along with an initial position and velocity vector for 1.17 radar data were processed in the NITE program to obtain an impact point. The drag parameter used was obtained from MSFC data, assuming this piece was a tumbling SRB segment.

Specifically, using $C_D = 1.0$ and $W = 31.5$, A gives the drag parameter,

$$\frac{C_D A}{W} = \frac{(1)\,A}{(31.5)\,A} = \frac{1}{31.5} = .032$$

Notice that with this model the "ballistic" coefficient is independent of the size of the piece. The coefficient however, is highly dependent upon the assumption for C_D.

4.5 Object Weights

4.5.1 Estimates of Object Weight

Computer program NITE can solve for the "ballistic coefficient" product-quotient where $\frac{C_D A}{W}$ where

C_D = Coefficient of drag
A = Surface Area
W = Weight

If one assumes that C_D and A are known, then W can be computed using the formula

$$W = C_D A \div \left(\frac{C_D A}{W}\right)$$

Using C_D and the reference area A obtained from MSFC, estimated weights are

R	73,500 lbs
RA	10,300 lbs

RB	4,200 lbs
RC	5,800 lbs
RD	No estimate—insufficient data

Estimates of empty weight for the SRB segments as provided by MSFC are:

Aft Section	77,000 lbs
Center Section	21,000 lbs
Forward Section	26,000 lbs

Note that Object R appears to be a major portion of the Aft Segment. Other objects (RA, RB, RC) appear to be less than one-half of the forward and center segments.

Early underwater photographs indicated that the booster pieces had a layer of unburned fuel attached. Unburned fuel would increase the object weight without significantly modifying the drag coefficient or reference area. Both TV and film indicated that fuel was still glowing after destruct. This additional and possibly changing weight could have an important effect on the ballistic trajectory and several models were analyzed to determine its significance in impact locations. Although the fuel might increase the initial weight by 30%, it was expected to be largely burned off before the objects entered the denser atmosphere where the ballistic coefficient has greater effect. An impact uncertainty of approximately 0.7 nm could be expected in impact location due to this effect. The uncertainty in impact time is considerably greater but has little importance to recovery operations.

4.5.2 Comments on Weight Estimates Using Short Spans of Data

To investigate how well a weight can be determined from relatively short spans of data, several computer runs were made using short spans of Radar 1.17 data. Using data from 115-125 seconds at 10 pps resulted in a weight estimate of 75,400 lbs for the aft section.

Using data from 115-120 seconds at 10 pps resulted in a weight estimate of 91,600 lbs for the aft section.

These estimates are to be compared to the estimate of 73,500 lbs obtained by using data from the total tracking span of 115-270 seconds.

4.5.3 The Effect of Drag Parameter on Impact Location

If C_D and A are considered known, then the unknown variable in C_DA/W is, of course, the weight W. Inaccurate estimates of W result in inaccurate estimates of C_DA/W. When an inaccurate estimate of C_DA/W is used in the computation of an impact point, that impact point is in error. A measure of the effect of C_DA/W will now be given.

Using the initial position and velocity associated with Object RA, trajectories were generated using different weights. Impact points were obtained using weights of 21,000 lbs, 10,500 lbs and 5,000 lbs. The impact location associated with 10,500 lbs was 3.3 nm from the impact location associated with the 21,000 lb weight. The impact location associated with using a weight of 5,000 lbs was 6.2 nm from the impact location obtained using a weight of 21,000 lbs.

5.0 *Condensed Chronology of Right SRB Observations*

Following the structural break-up at T+73 seconds, the right Solid Rocket Booster continued under thrust for approximately 37 seconds. It was tracked continuously by Radar 1.17 and Ponce de Leon MIGOR. Radar 0.14 and the UCS-15 IFLOT tracked briefly as shown in Figure 1.

Analysis of the PDL MIGOR video tape shows the SB to be rolling clockwise viewed from aft approximately once every 10 seconds during the powered flight period. Possibly this period decreased by about 1.5 seconds during the 37 seconds of powered flight indicating an angular acceleration about the longitudinal axis.

From T + 93.6 to T + 95.8 seconds Radar 0.14 detected a number of small objects separating from the main target (Figures 6 and 7.). None of these objects were visible to the optics sites or on the radar boresight video tape. Enough data could be extracted to permit a trajectory estimate to be made for one of these objects (designated RD on Figure 2). Impact was at approximately T+398 seconds, and the separation speed relative to the main SRB body was on the order of 123 meters/second.

At T + 110.3 seconds Range Safety issued a command destruct to the Solid Rocket Booster. The shock wave from the destruct explosion of the right SRB was visible on the UCS-15 E-705 16mm camera (Figure 15), permitting a computed estimate of the explosion at time T+110.275 seconds. The propagation speed of the shock wave was on the order of 1,000 m/s during the first few hundredths of a second with the expansion slowing to essentially zero within .1 second.

Following the command destruct, the SRB separated into a number of fragments as shown by the photos Figures 11 through 14. Optical resolution was not sufficient to permit the identification of these fragments. Radar 1.17 and PDL MIGOR continued to track a large piece later identified as part of the aft segment and skirt. A number of smoke trails, possibly two dozen small (pinpoint) glowing objects, and four bright glowing objects could be seen on the UCS-15 IFLOT 70mm flim. The four bright glowing objects and possibly three smoke trails were also seen on the PDL MIGOR video tape. The radar boresight video tape showed no visible object after the command destruct.

Because the smoke trails are at the limit of the PDL MIGOR video resolution, first priority was given to the three bright glowing objects not tracked by Radar 1.17. Triangulation on these Objects (RA, RB, and RC) was possible for periods of 4 to 6 seconds, and impact trajectories have been generated. Table 1 lists the impact times and positions and Figure 2 is a map showing the ground traces of the tracked (solid) and projected (dotted) trajectories. Separation speeds relative to the booster aft segment ranged from 45 m/s to 120 m/s.

From T+115 to T+141 seconds, and object flashing twice per second was in the PDL MIGOR field of view (Figure 10). It appears after image enhancement to originate from the aft segment of the right SRB.

The FAA radar observations cannot be positively associated with the right or the left SRB. The six initial impact estimates are shown in Table 1 and the next 11 estimates are listed in Table 4.

TABLE 1: IMPACT ESTIMATES AND UNCERTAINTY ELLIPSE

Map ID	T+sec	N. Lat	W. Long.	Semi-Maj Axis,nm	Semi-Mnr Axis,nm	Az of Maj Axis	Confirmation as Right SRB
R	286	28°49'09.5"	79°52'28.6"	.006	.004	158°	Radar, Optics Observations
RA	402	28°43'41.9"	80°04'26.9"	1.4	.1	61°	Optics Obs; Radar Transformations
RB	511	28°41'25.8"	80°07'23.2"	2.1	.2	53°	
RC	464	28°42'19.1"	80°06'32.4"	3.3	.3	59°	
RD	398	28°36'09.0"	80°16'18.2"	7.9	6.0	62°	DPDE Record of Separation
2	341	28°46'09"	80°02'29"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed
3	363	28°45'38"	79°56'57"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed
4	363	28°43'02"	79°53'10"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed
5	363	28°52'24"	79°56'27"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed
6	401	28°51'42"	80°04'27"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed
7	401	28°49'10"	79°58'25"	1.0	.4	120°	FAA AN/FPS-66; unconfirmed

NOTES: The FAA radar target identified by #1 was the same as target R.

TABLE 2: CALCULATED C-BAND RCS

SRB Section	Peak C-Band RCS (dBsm)
Segments 1-4 Combined	53.9 w/o Forward Skirt 54.6 with Forward Skirt
Segment 1*	42.3
Forward Skirt	33.7
Forward Cone	32.6 w/o Nose Cap
Aft Skirt	32.3

* Aft Segment

TABLE 3: DATA INPUT TO NITE PROGRAM

Object	Site	Data Type	Time Span	Frequency
R	1.17	RAE Recording	115.0 - 270.0	0.5 pps
RA	PDL	Video Recording	112.8 - 120.8	10 pps
	UCS-15	70 mm film	112.8 - 117.067	30 pps
		16 mm film	113.0 - 116.0	1 pps
RB	PDL	Video Recording	112.8 - 116.7	10 pps
	UCS-15	70 mm film	112.8 - 117.0	30 pps
		16 mm film	113.0 - 116.0	1 pps
RC	PDL	Video Recording	113.3 - 114.6	10 pps
			115.0 - 116.0	10 pps
			116.5 - 117.5	10 pps
	UCS-15	70 mm film	113.3 - 114.467	30 pps
			115.233 - 116.067	30 pps
			116.3 - 117.033	30 pps
RD	0.14	RTI Recording (Range)	92.0 - 95.5	2 pps

ETR CAMERA AND RADAR COVERAGE OF RIGHT SRB

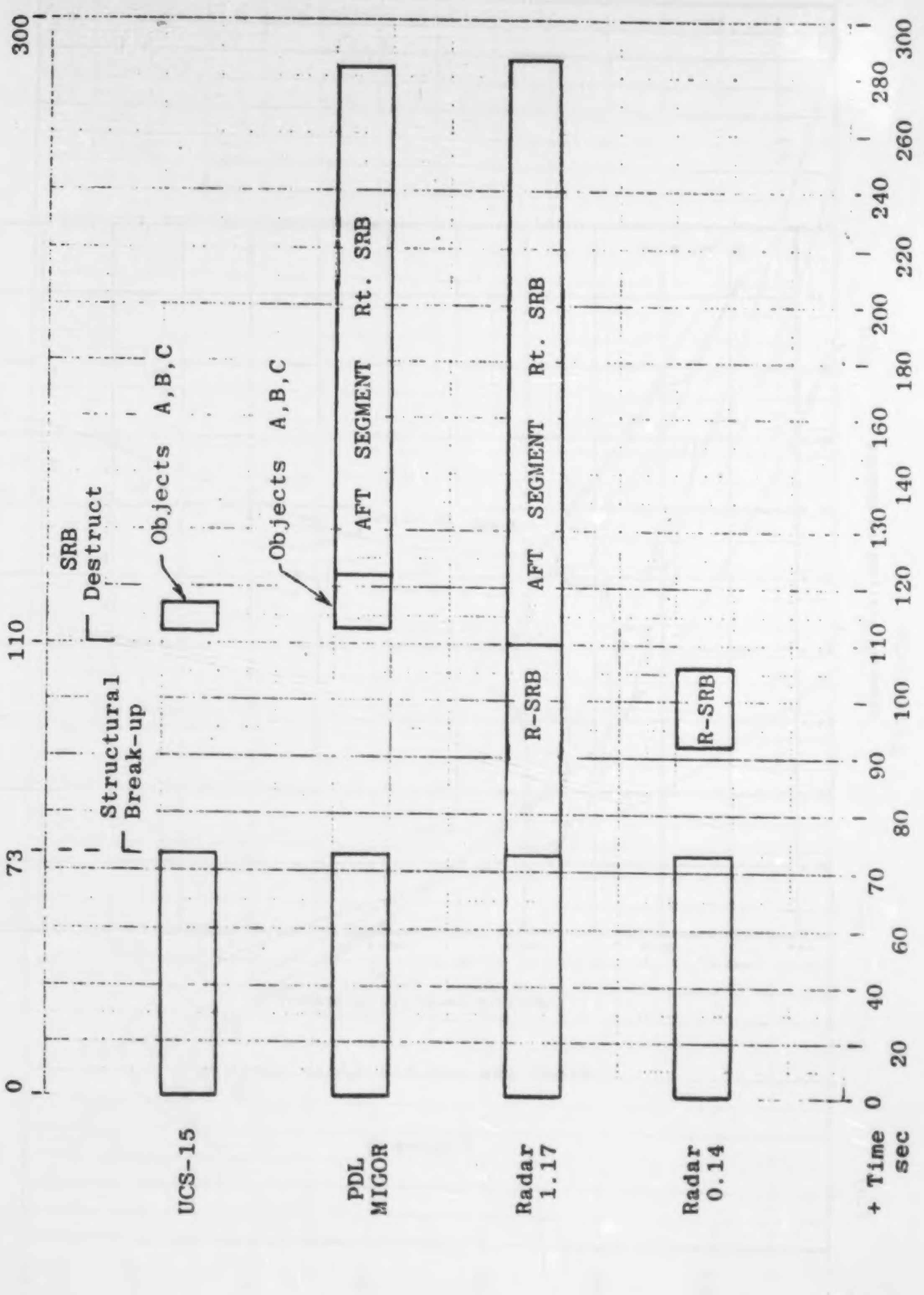
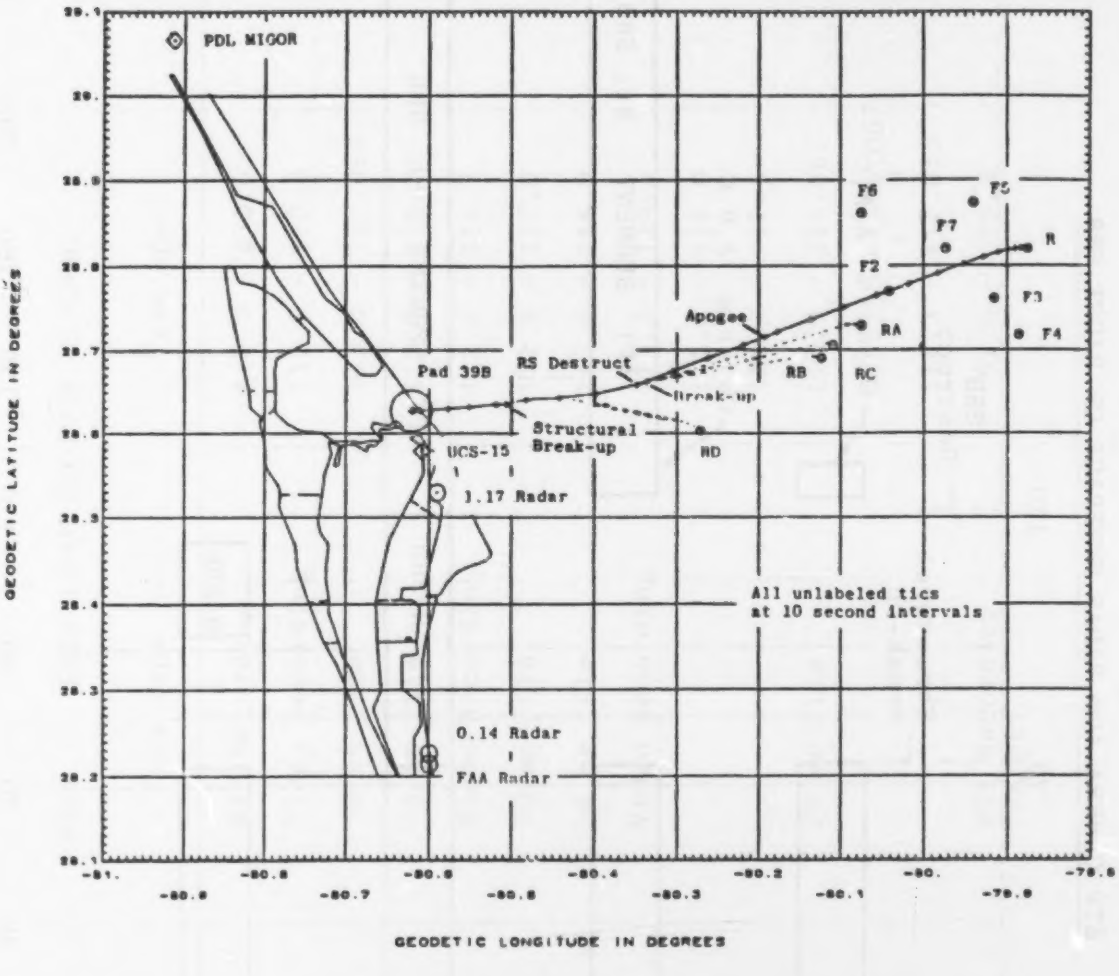


Figure 1



RIGHT SRB AND FAA RADAR IMPACTS

Figure 2

OBJECT ALTITUDE VERSUS TIME

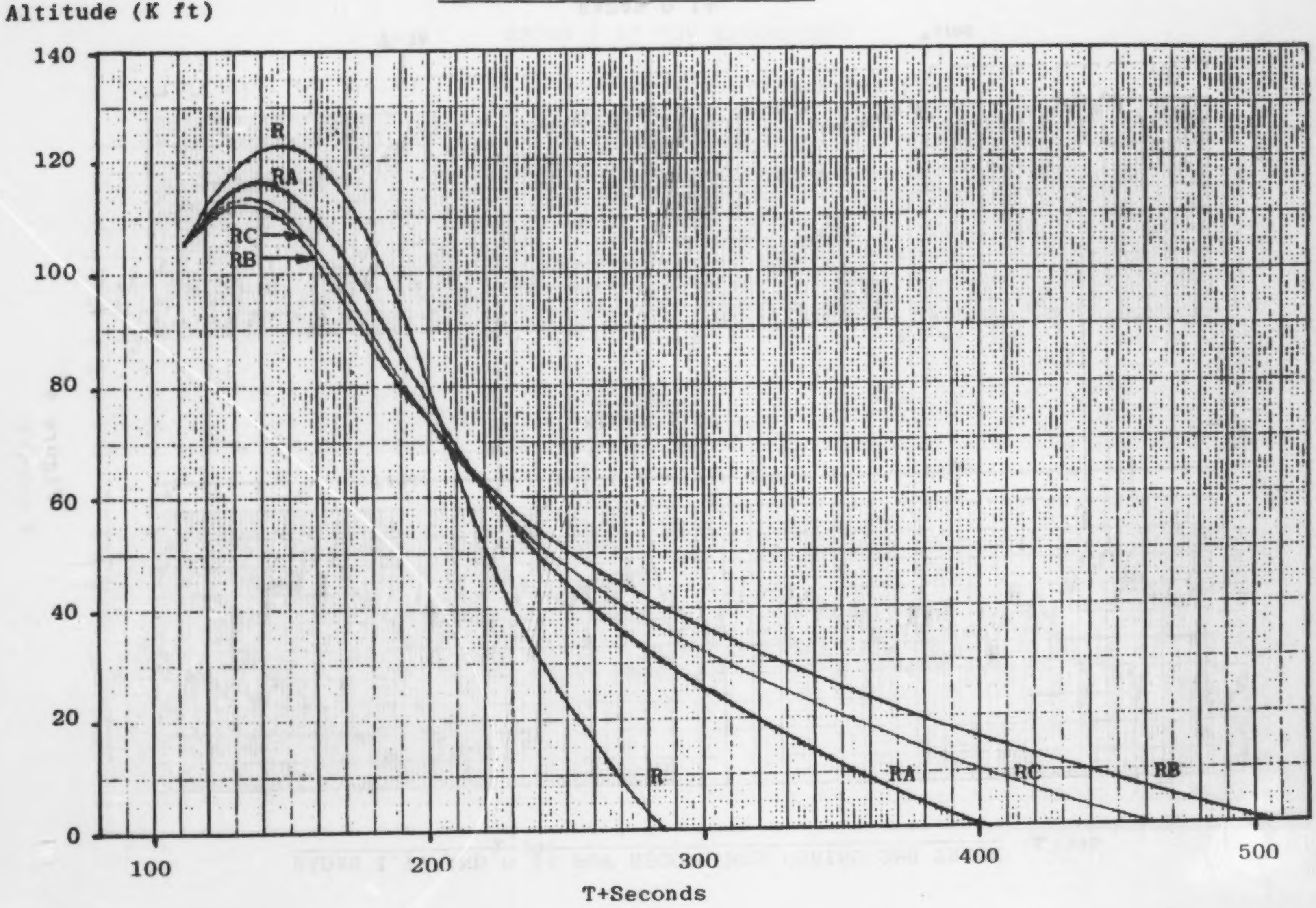


Figure 3

RADAR 1.17 AND 0.14 PDV RECORDINGS DURING SRB TRACK

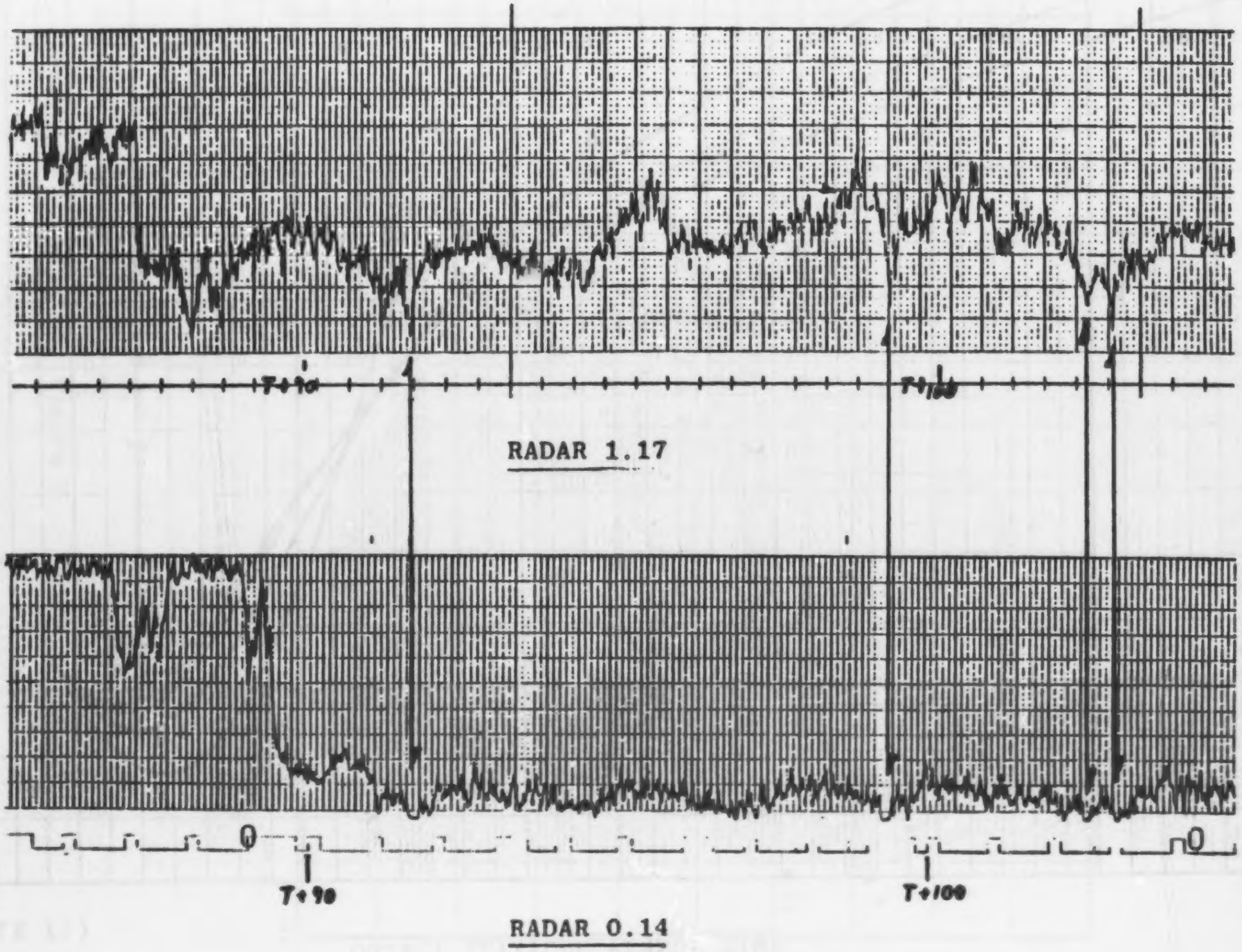
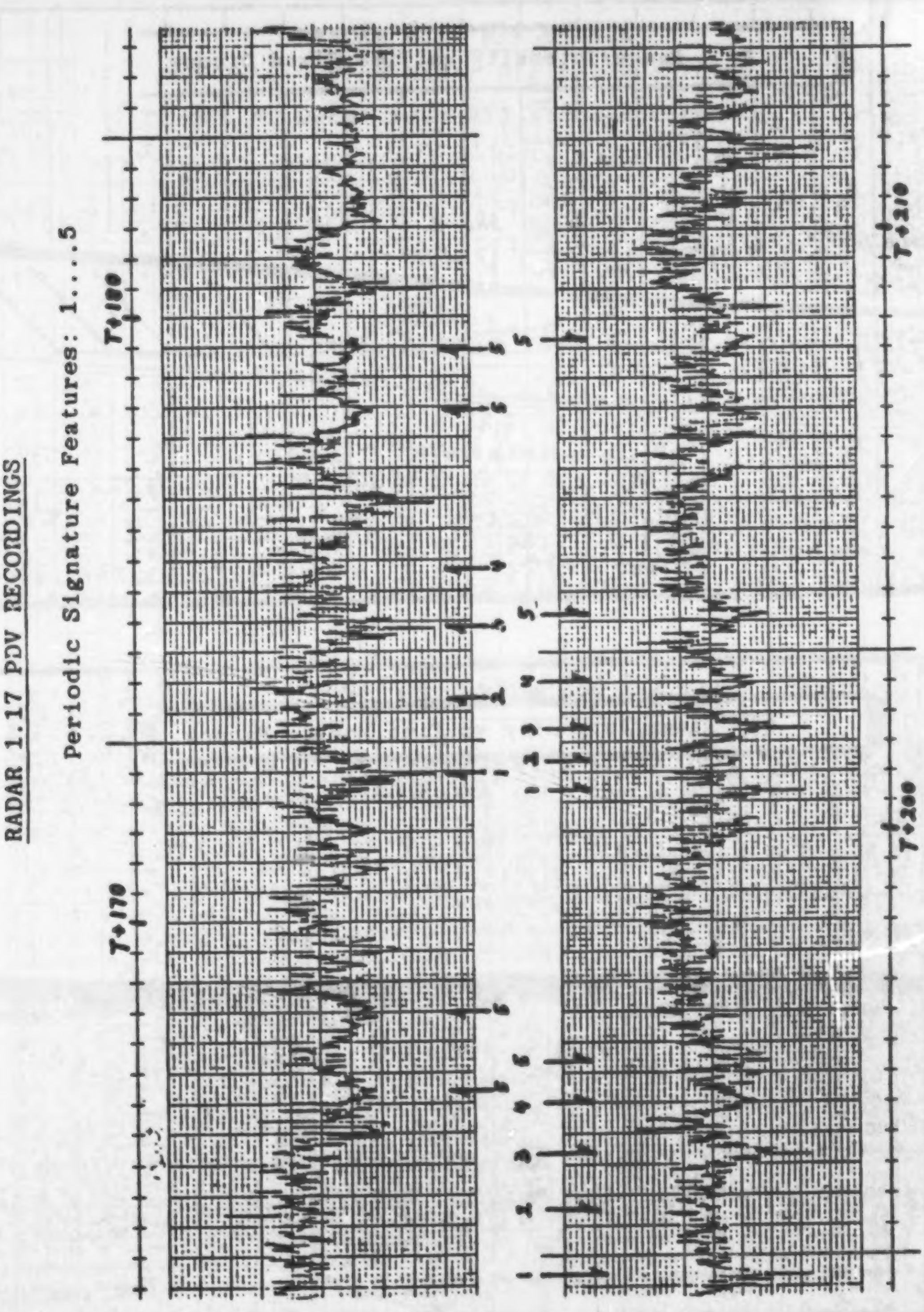


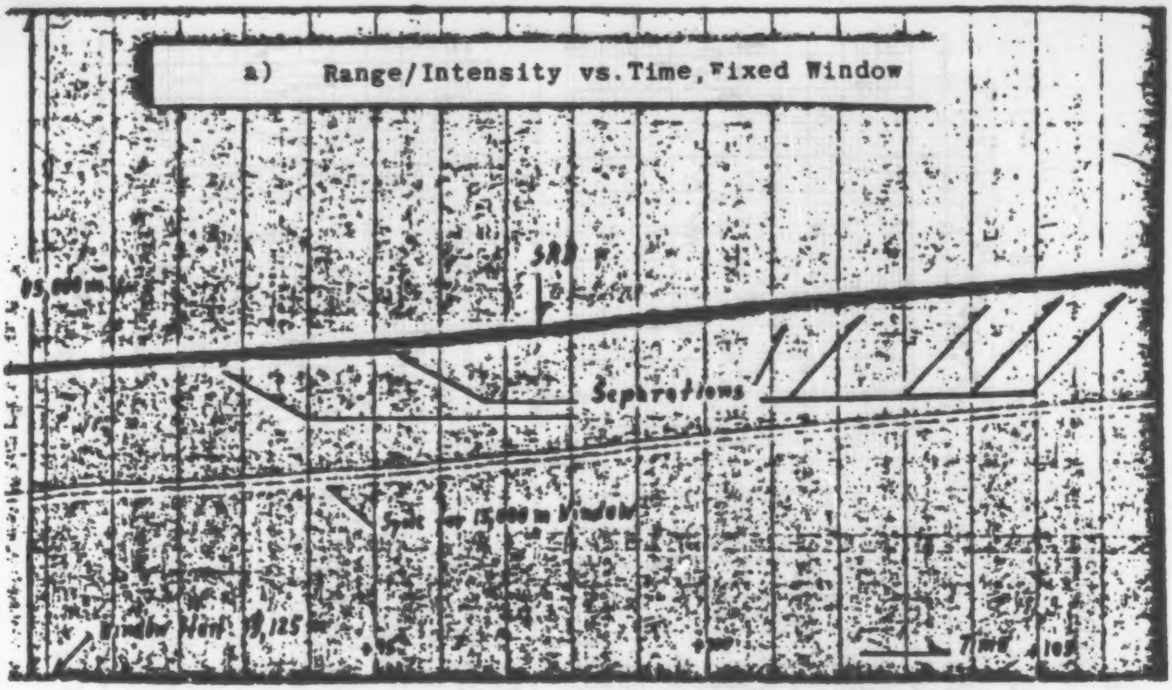
Figure 4



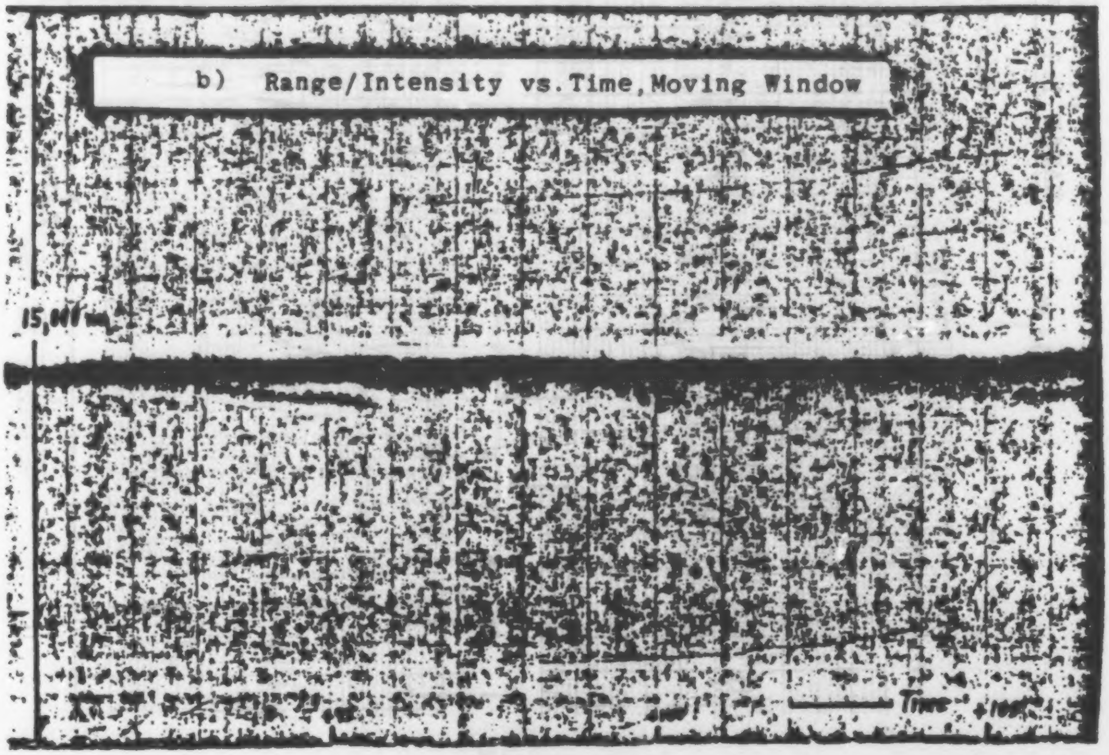
RADAR 1.17 PDV RECORDINGS

Periodic Signature Features: 1....5

Figure 5

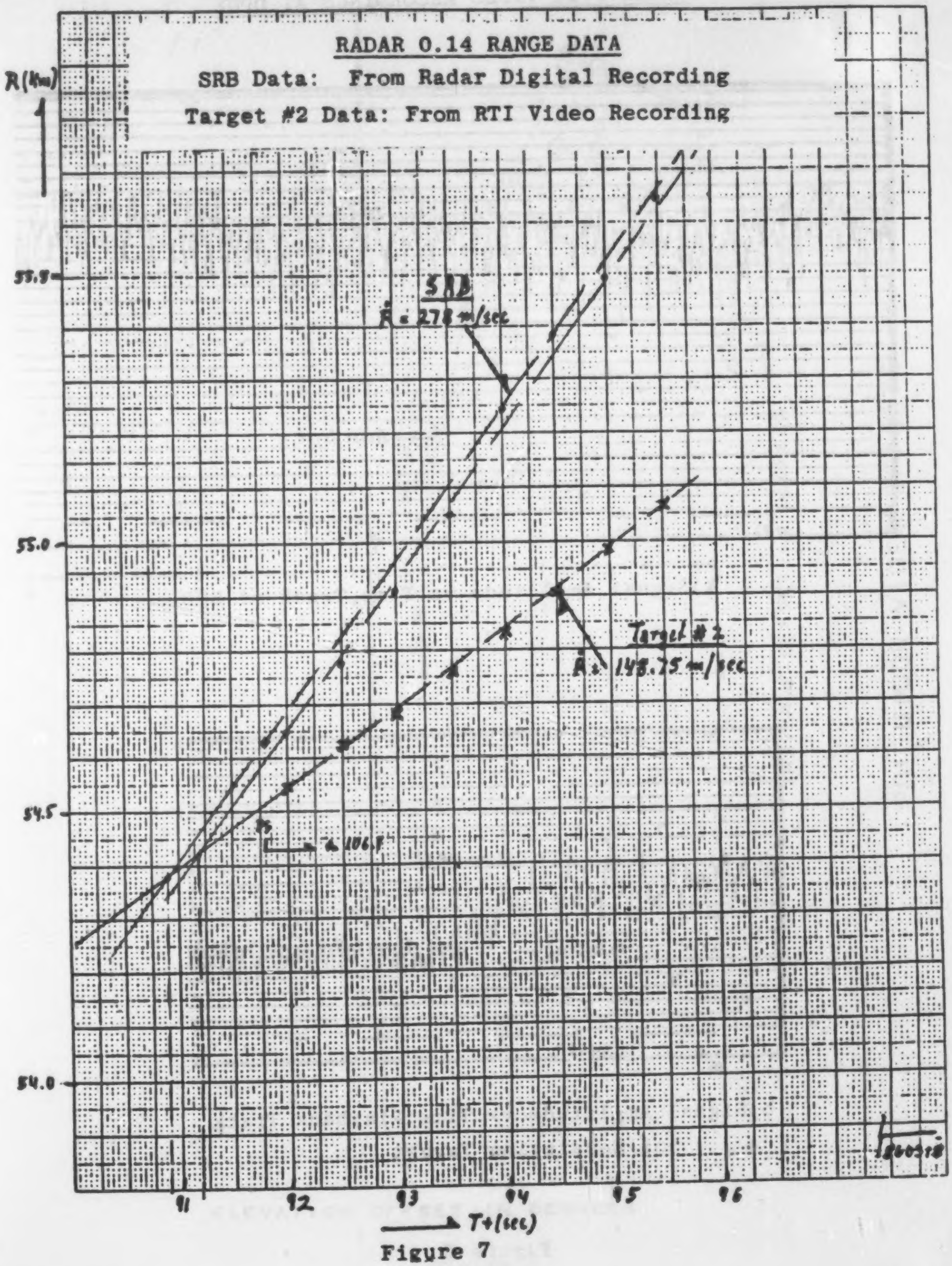


a) Range/Intensity vs. Time, Fixed Window



b) Range/Intensity vs. Time, Moving Window

Figure 6



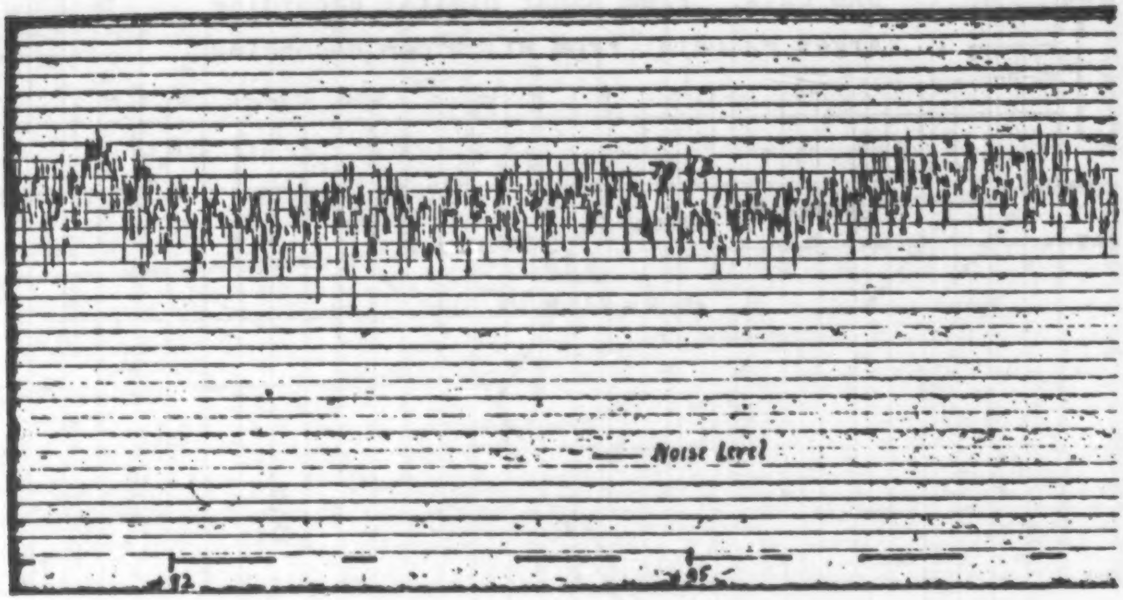
RADAR 0.14 RANGE DATA

SRB Data: From Radar Digital Recording

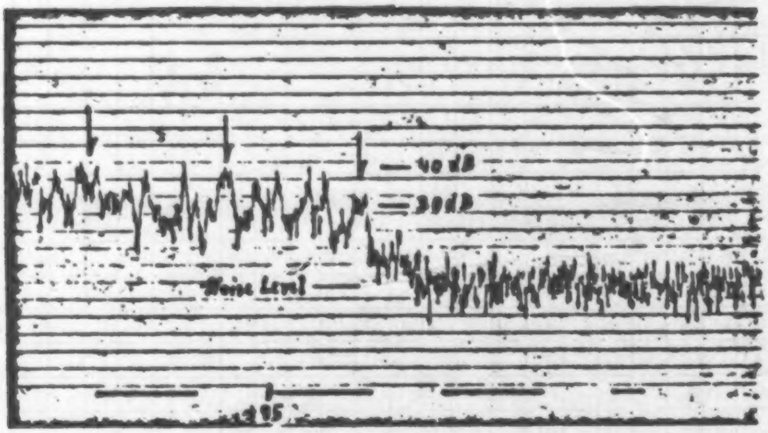
Target #2 Data: From RTI Video Recording

Figure 7

RADAR 0.14 VIDEO RECORDINGS AT DPDE



a)Signal Amplitude vs.Time,Track of SRB



b)Signal Amplitude vs.Time,Playback Track of Separating Target

Figure 8

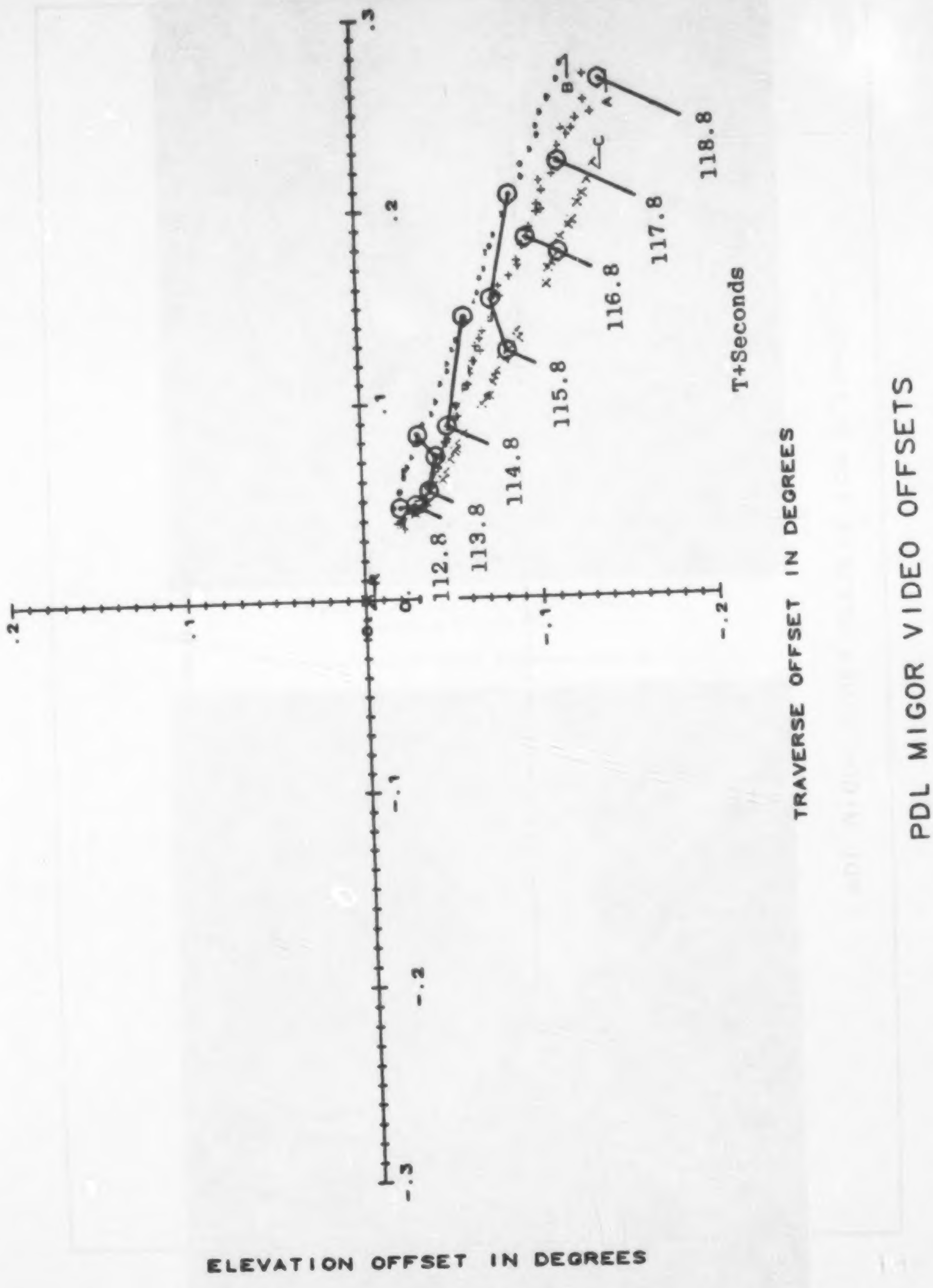

PDL MIGOR VIDEO OFFSETS
TRAVERSE OFFSET IN DEGREES
ELEVATION OFFSET IN DEGREES
T+Seconds
.3
.2
.1
0
-.1
-.2
-.3
112.8
113.8
114.8
115.8
116.8
117.8
118.8
A
B
C

Figure 9

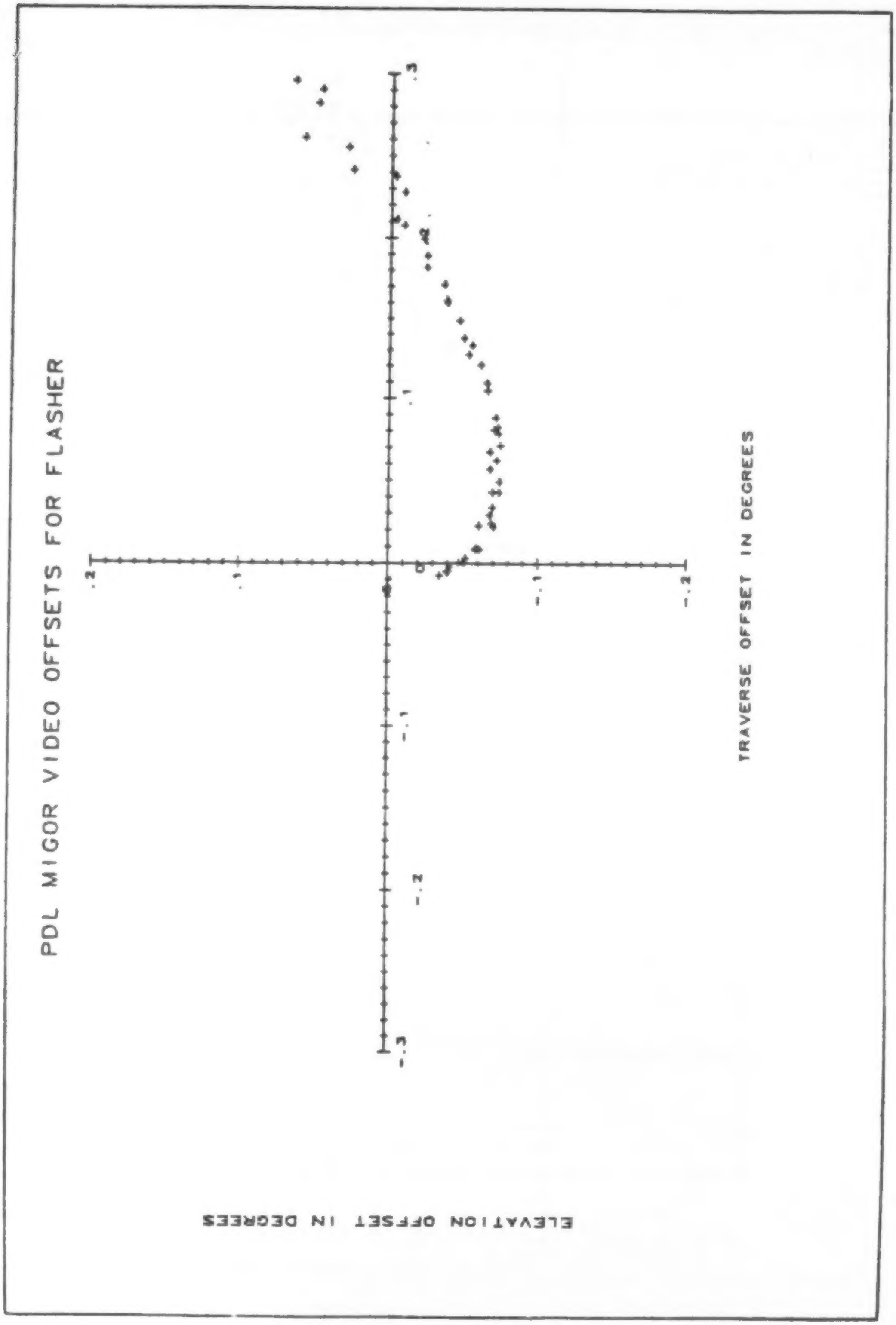

PDL MIGOR VIDEO OFFSETS FOR FLASHER
TRAVERSE OFFSET IN DEGREES
ELEVATION OFFSET IN DEGREES
.3
.2
.1
0
-.1
-.2
-.3
.2
.1
-.1
-.2

Figure 10

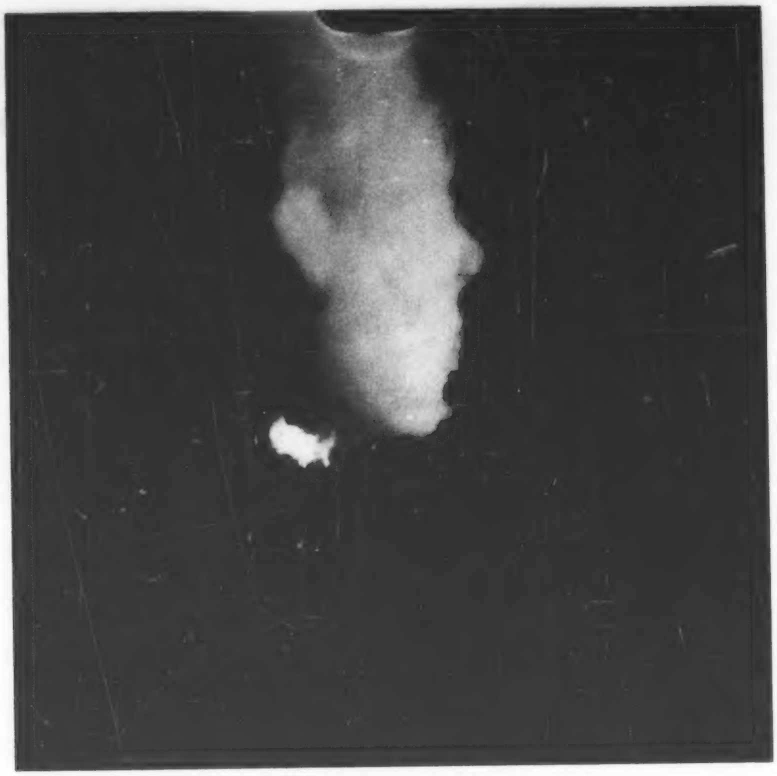


Figure 11. Right SRB T+111.026 Seconds
Instrument: UCS-15 IFLOT

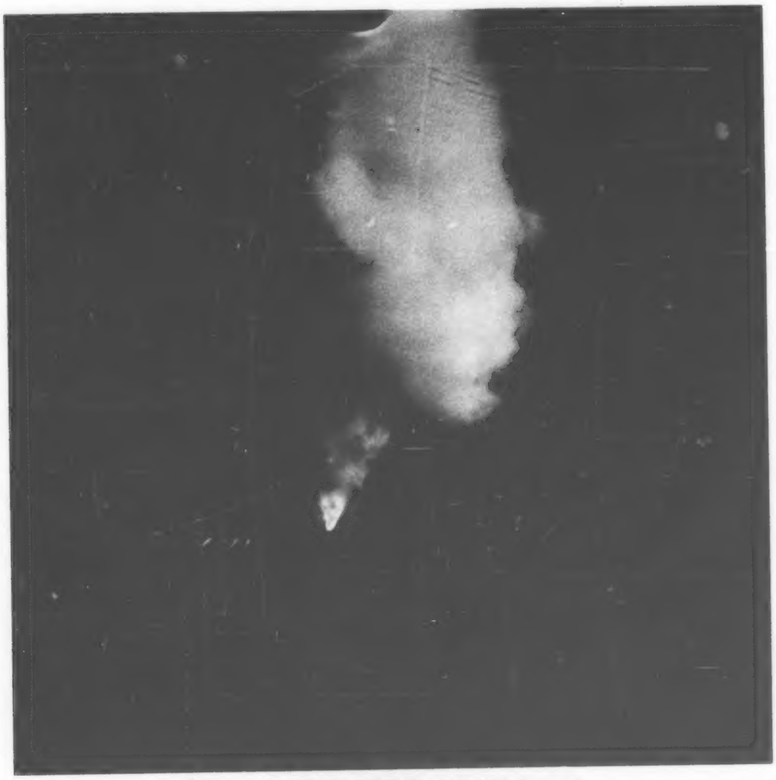
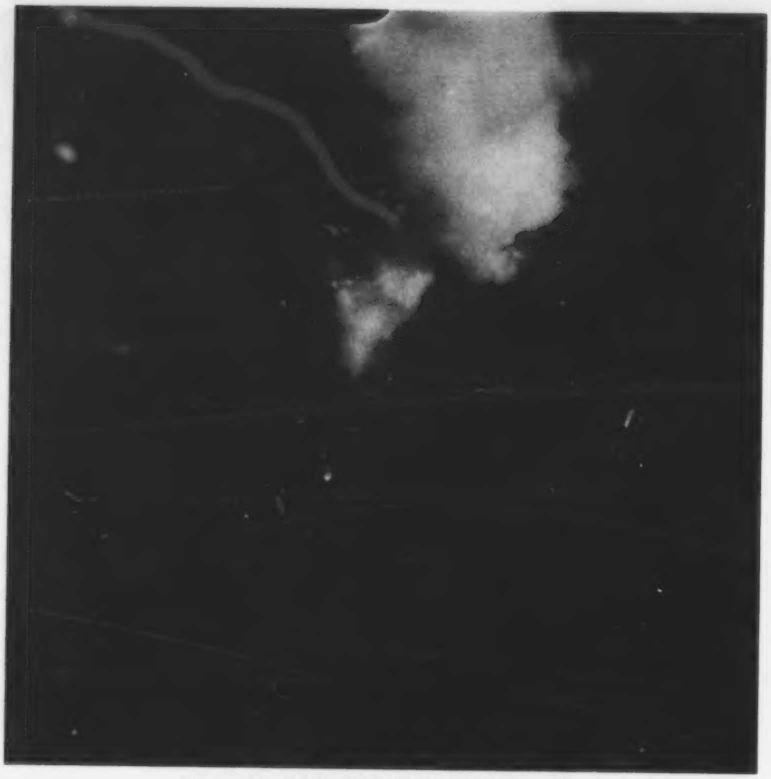


Figure: 12. Right SRB T+112.026 Seconds
Instrument: UCS-15 IFLOT



Figuer 13. Right SRB T+113.026 Seconds
Instrument: UCS-15 IFLOT

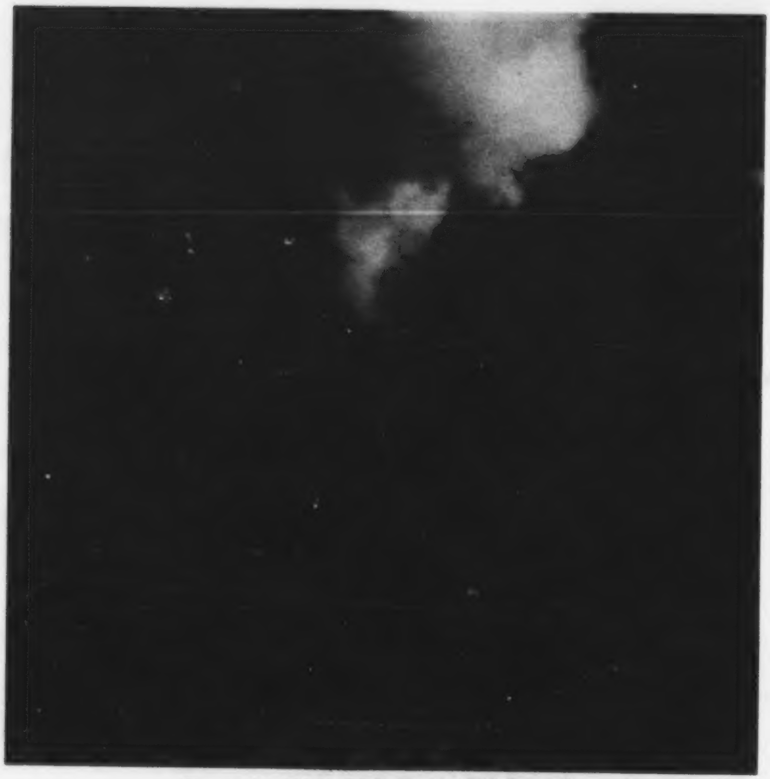


Figure 14. Right SRB T+114.026 Seconds
Instrument: UCS-15 IFLOT

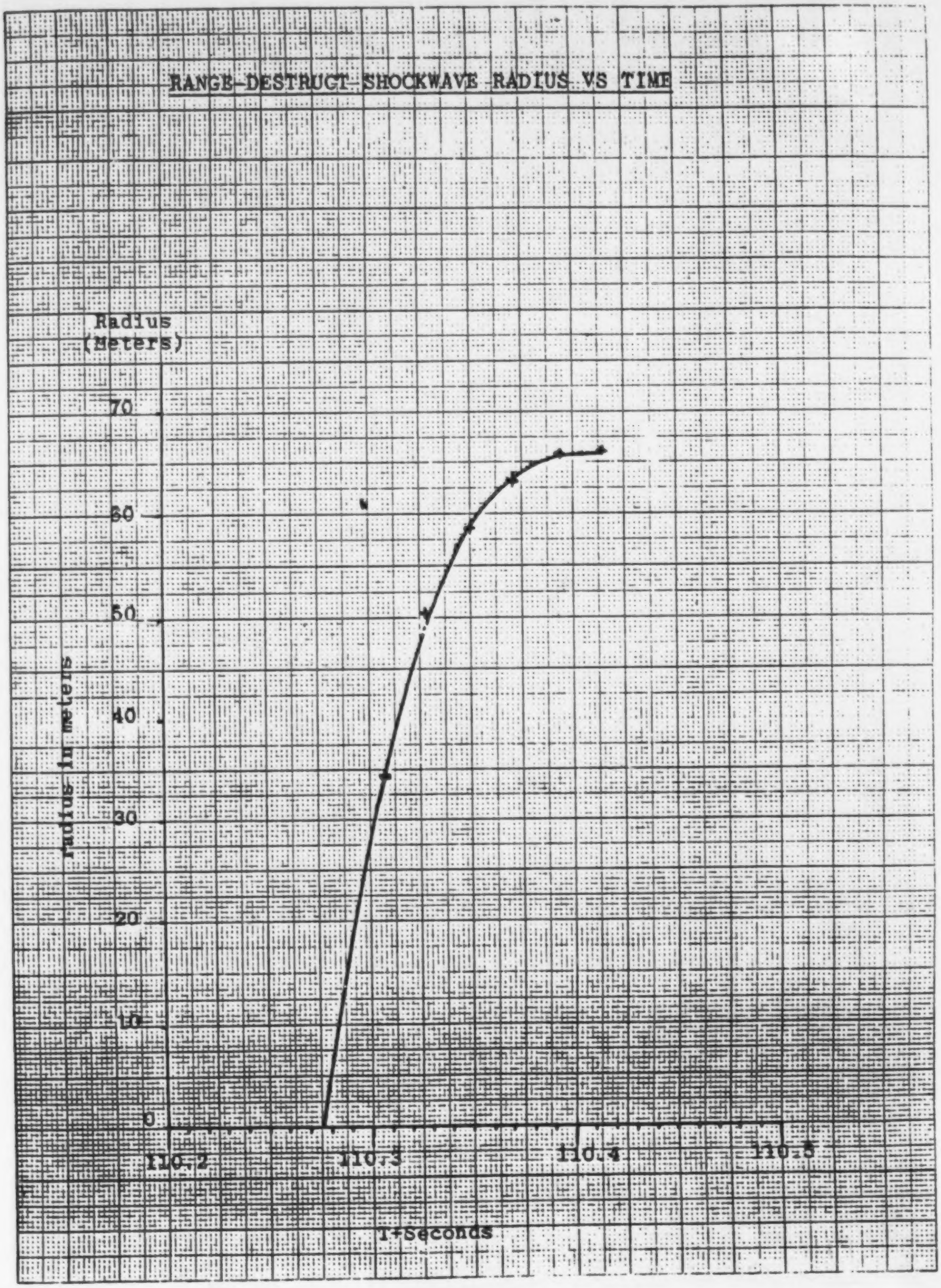

RANGE-DESTRUCT SHOCKWAVE RADIUS VS TIME
Radius
(Meters)
Radius in meters
70
60
50
40
30
20
10
0
110.2
110.3
110.4
110.5
T+Seconds

Figure 15

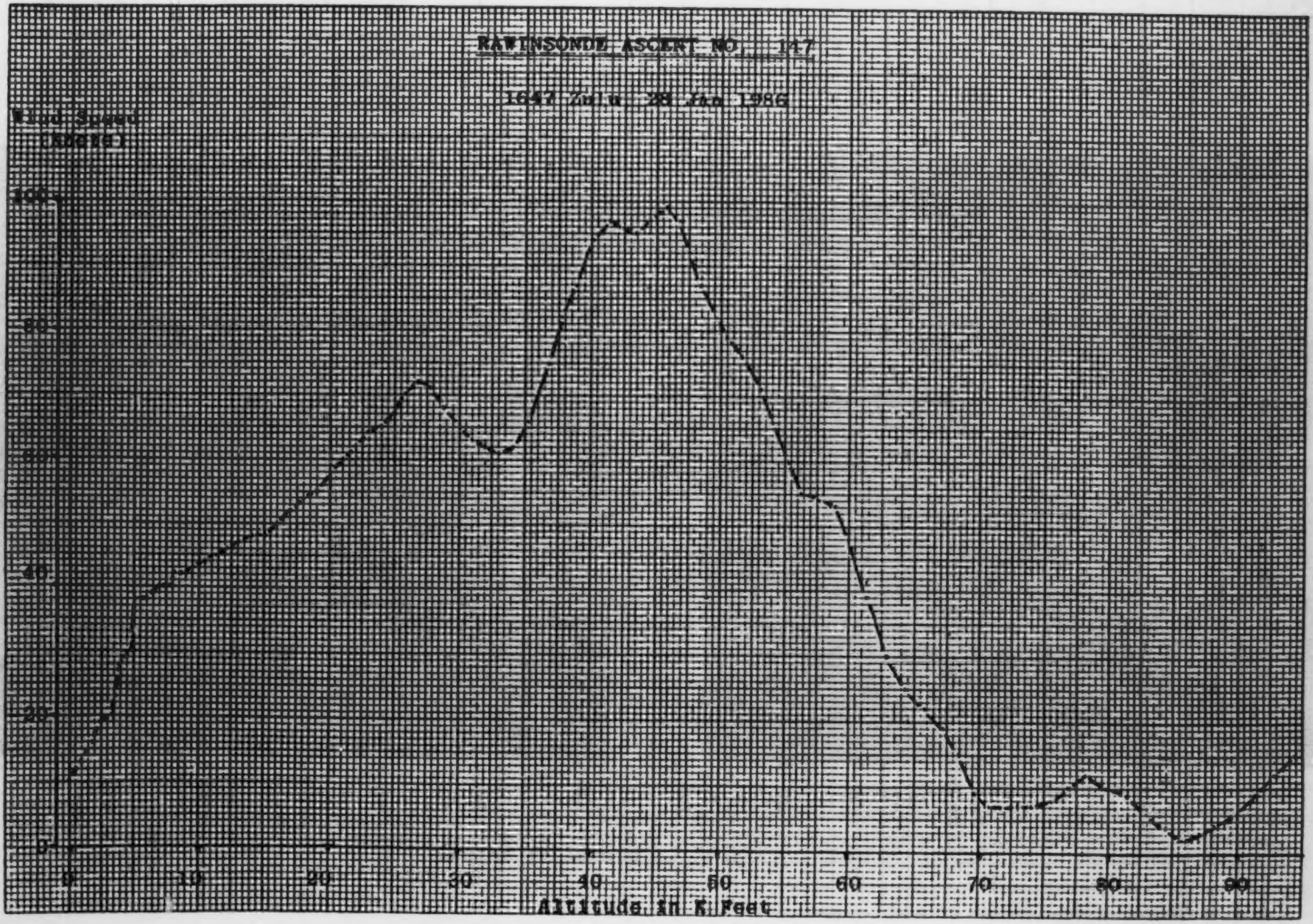

RAWINSONDE ASCENT NO. 147
1647 Zulu 28 Jan 1986
Wind Speed (Knots)
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Altitude in K Feet

Figure 16

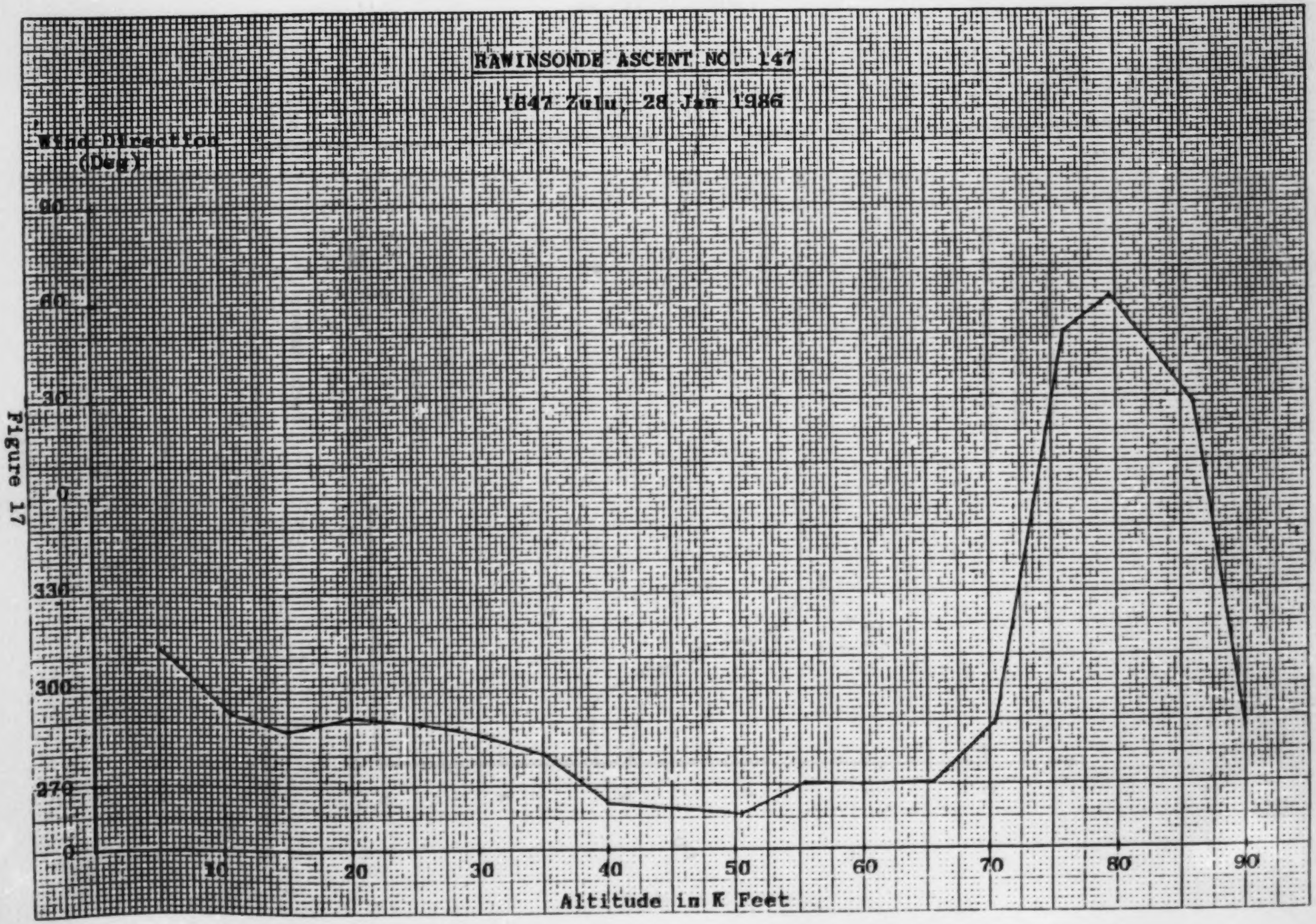

RAWINSONDE ASCENT NO. 147
1847 Zulu, 28 Jan 1986
Wind Direction
(Deg)
90
60
30
0
330
300
270
0
10
20
30
40
50
60
70
80
90
Altitude in K Feet

Figure 17

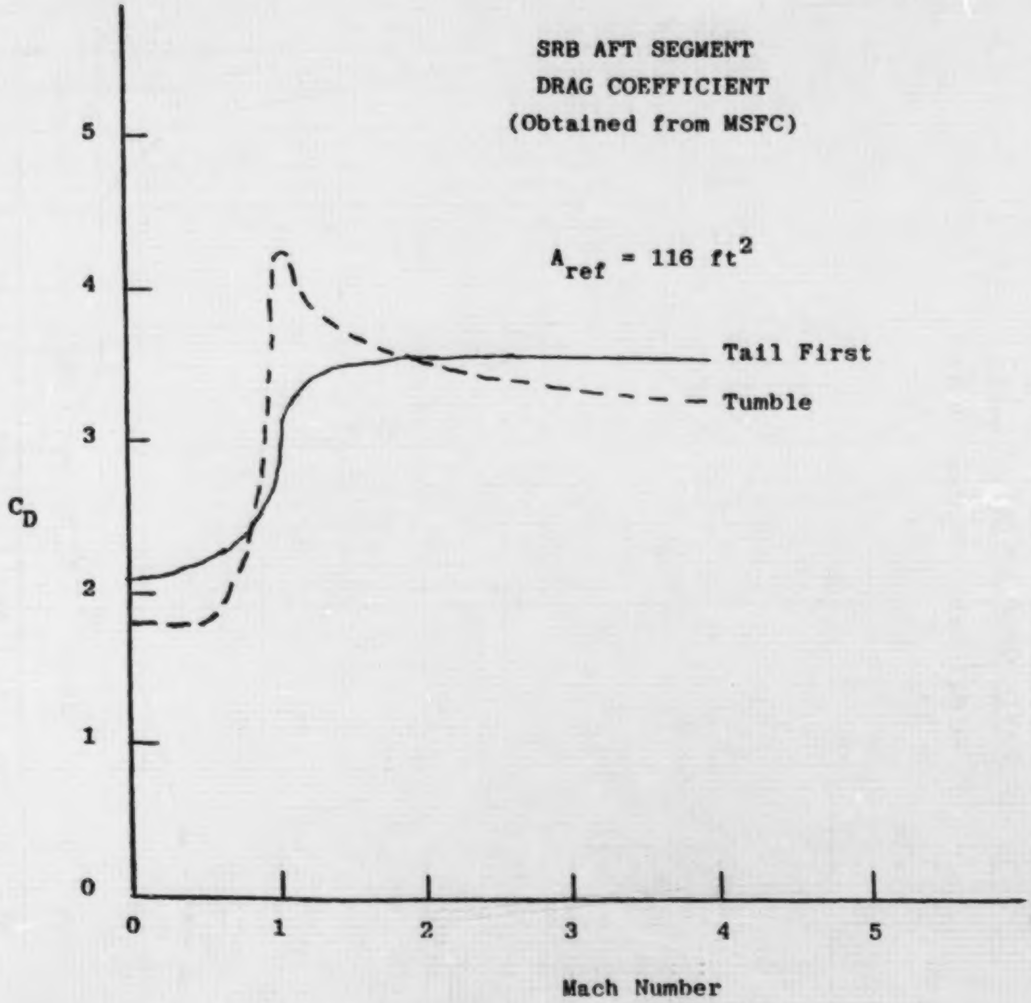
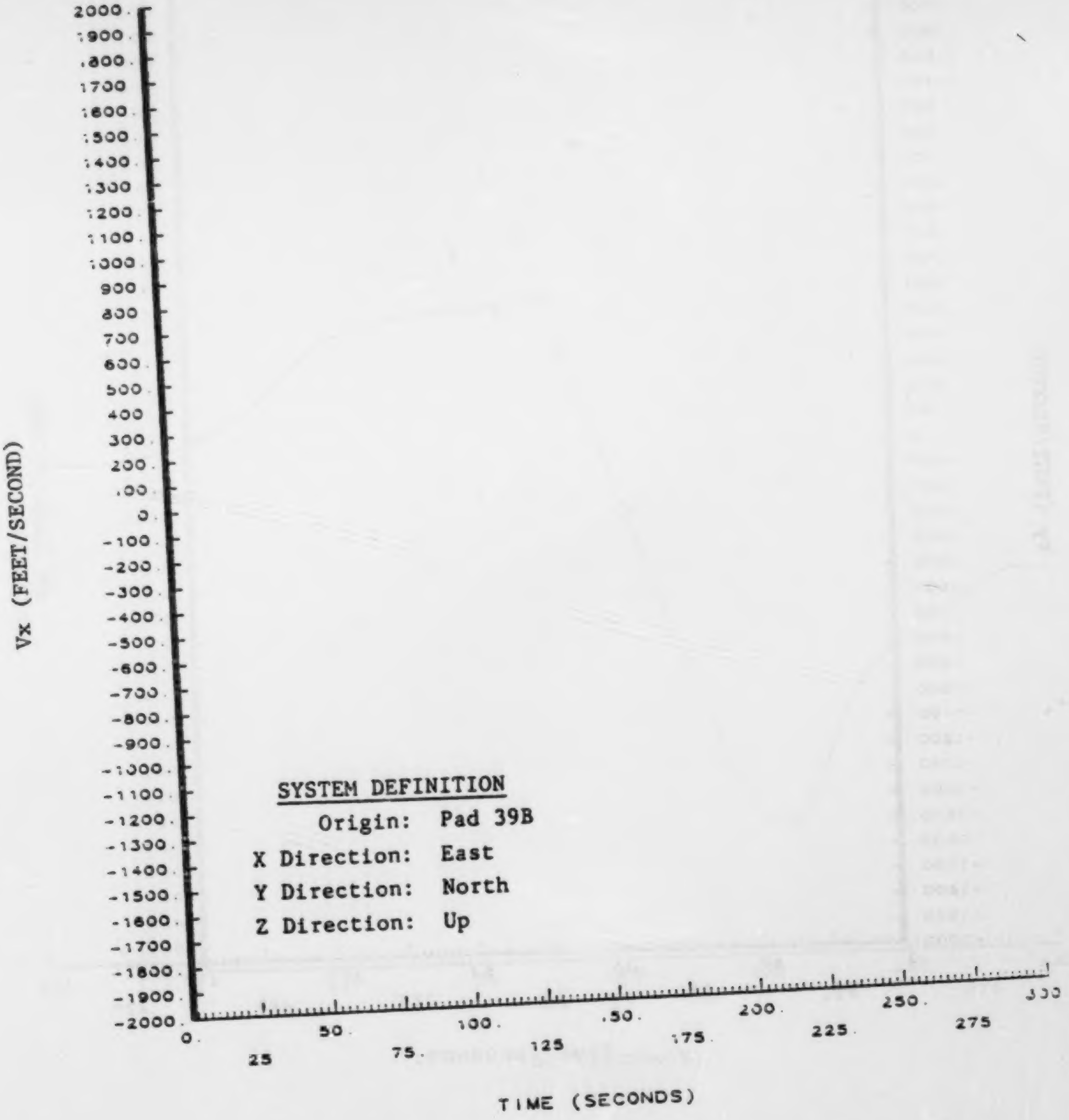

SRB AFT SEGMENT
DRAG COEFFICIENT
(Obtained from MSFC)
A_{ref} = 116 ft^2
Tail First
Tumble
C_D
0
1
2
3
4
5
0
1
2
3
4
5
Mach Number

Figure 18



SYSTEM DEFINITION

Origin: Pad 39B
X Direction: East
Y Direction: North
Z Direction: Up

Figure 19

OBJECT R VELOCITY DATA

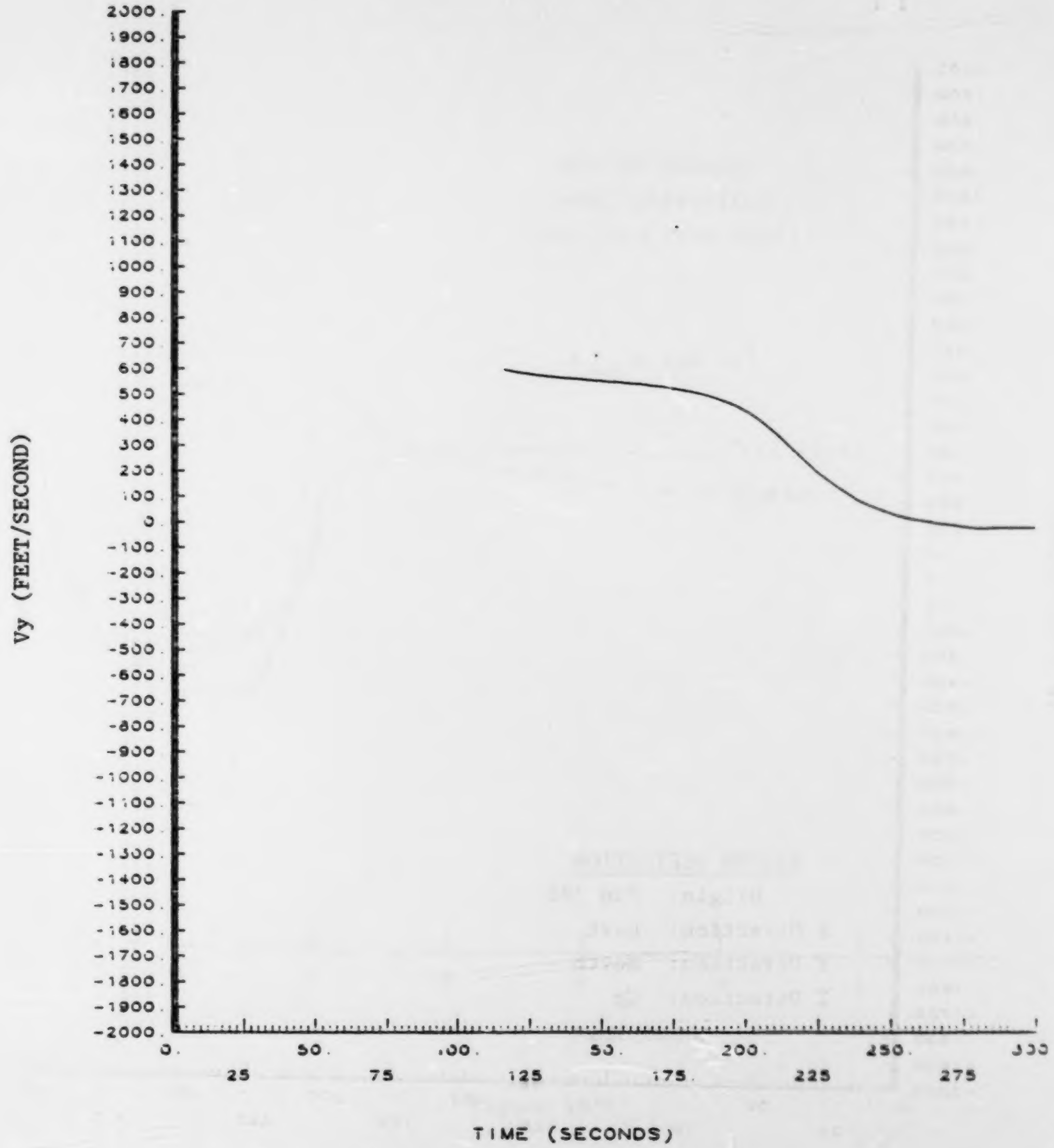


Figure 20

OBJECT R VELOCITY DATA

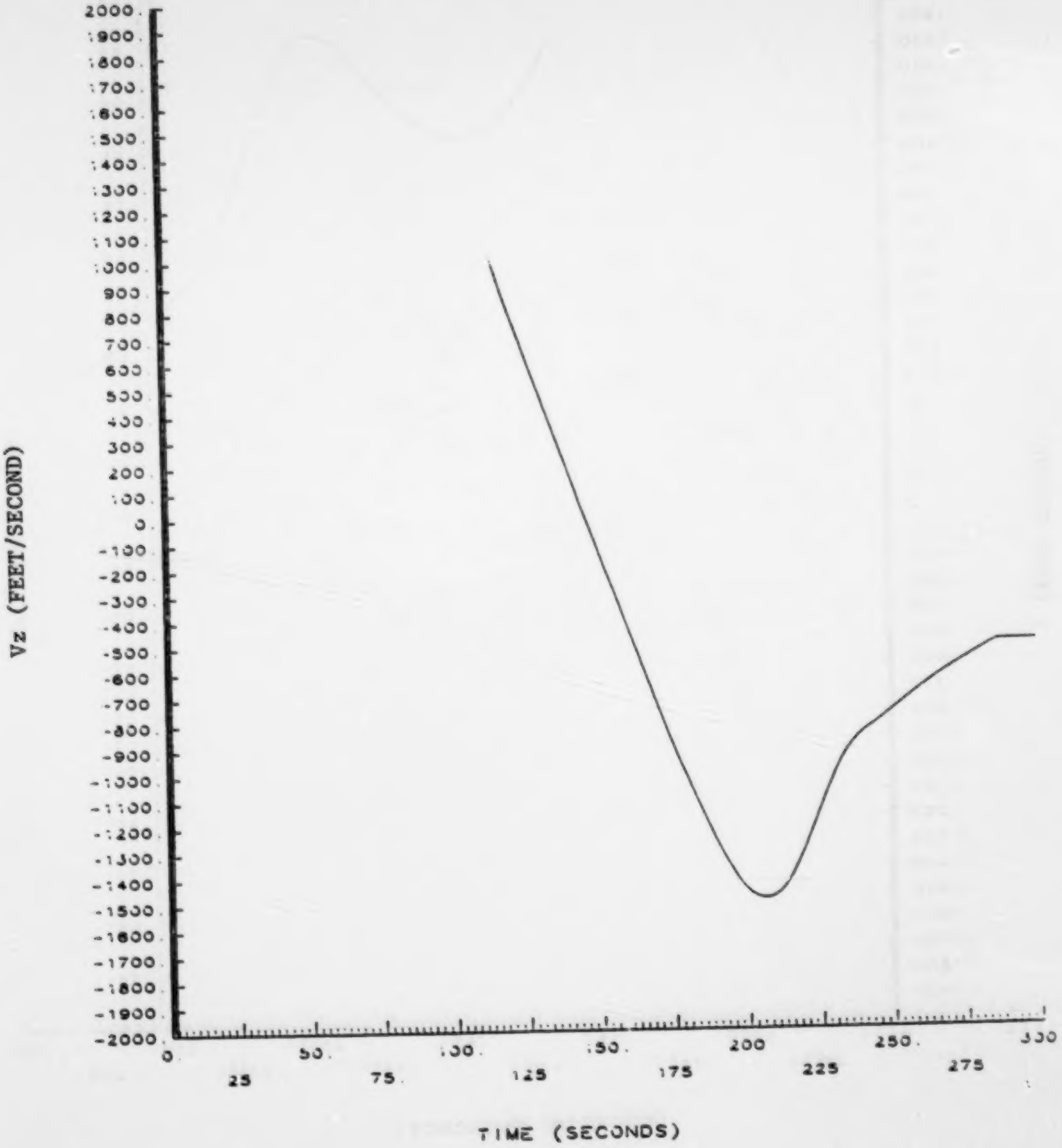


Figure 21

OBJECT R VELOCITY DATA

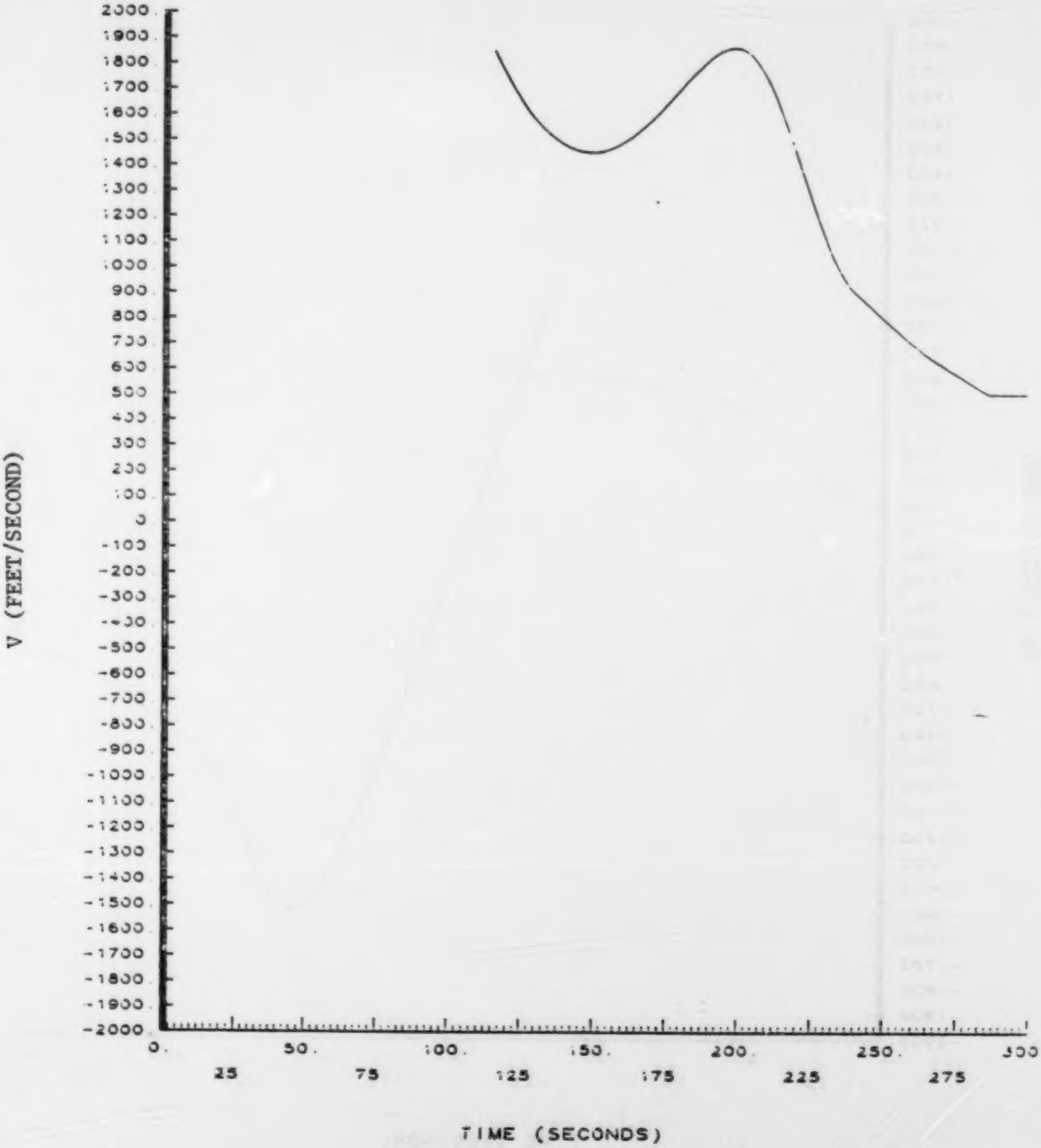


Figure 22

OBJECT R ACCELERATION DATA

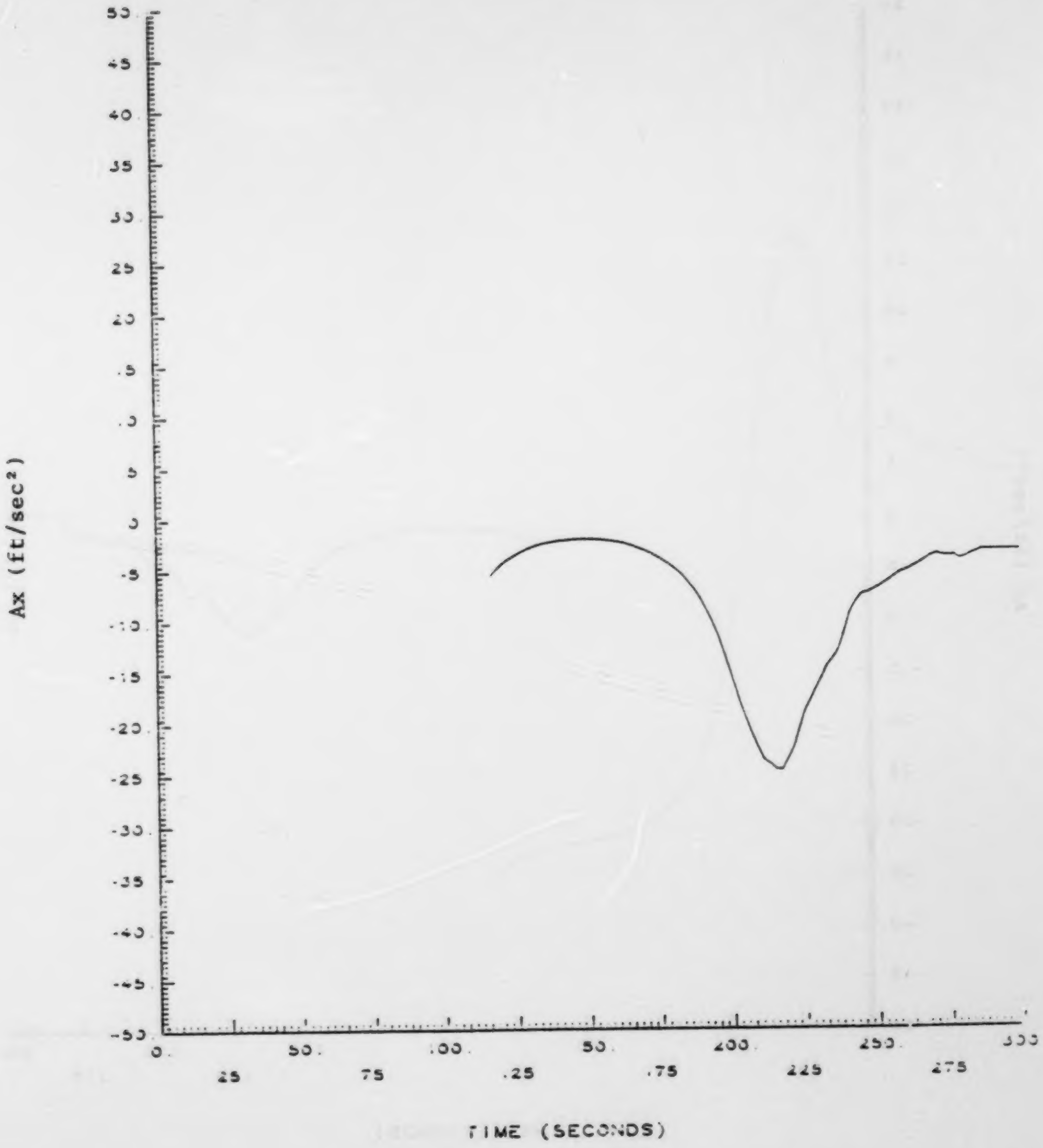


Figure 23

OBJECT R ACCELERATION DATA

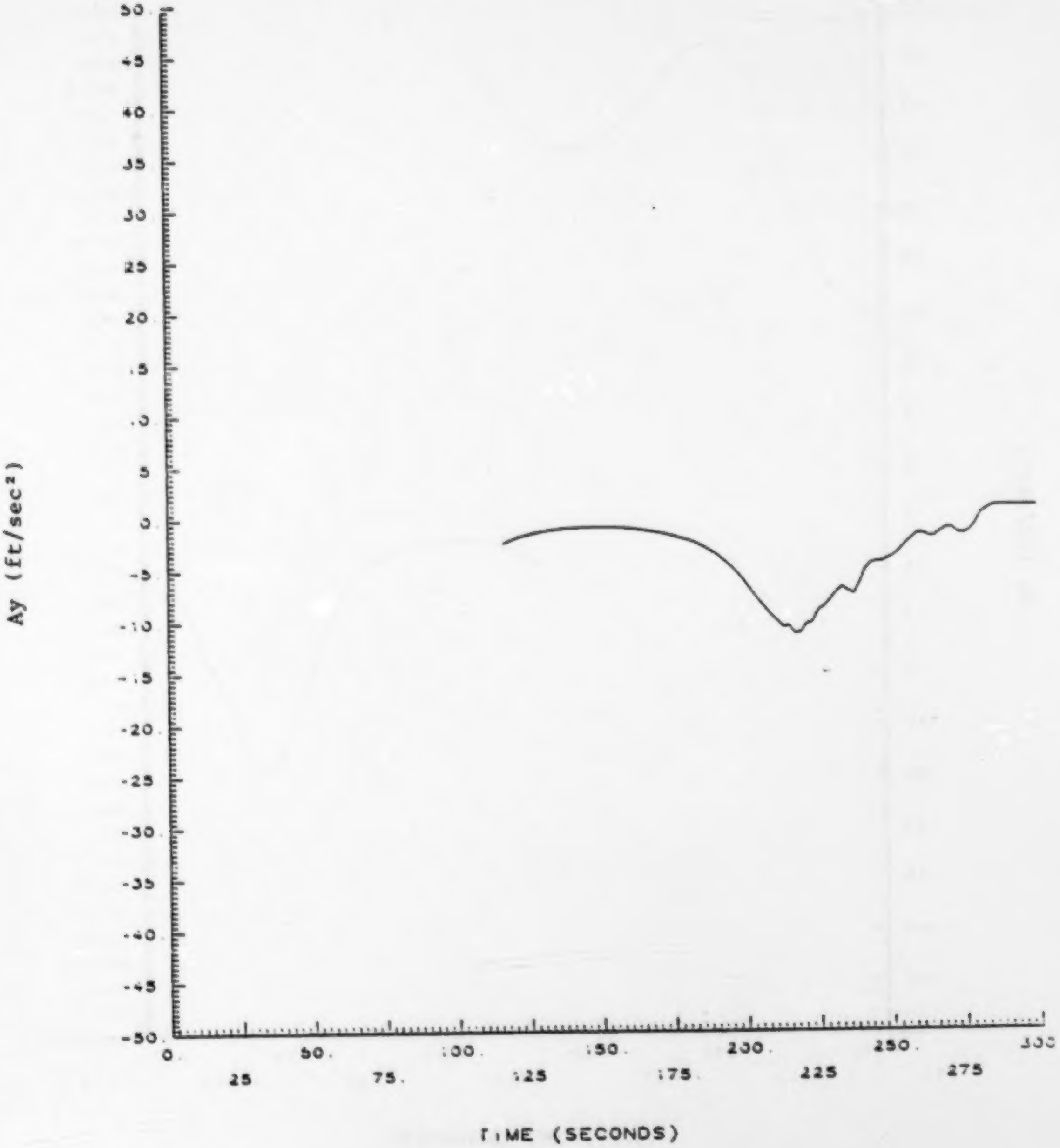


Figure 24

OBJECT R ACCELERATION DATA

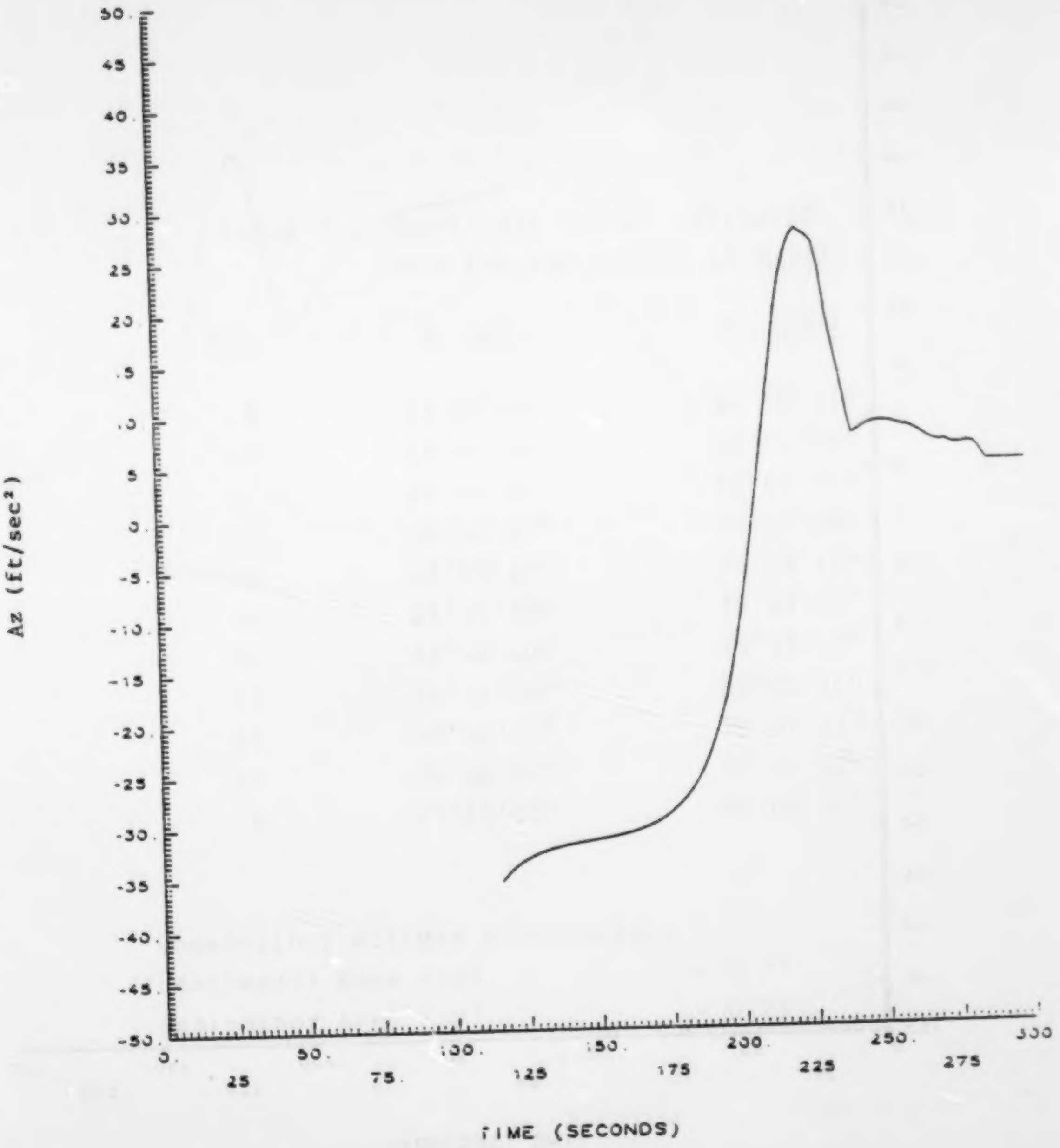


Figure 25

OBJECT R ACCELERATION DATA

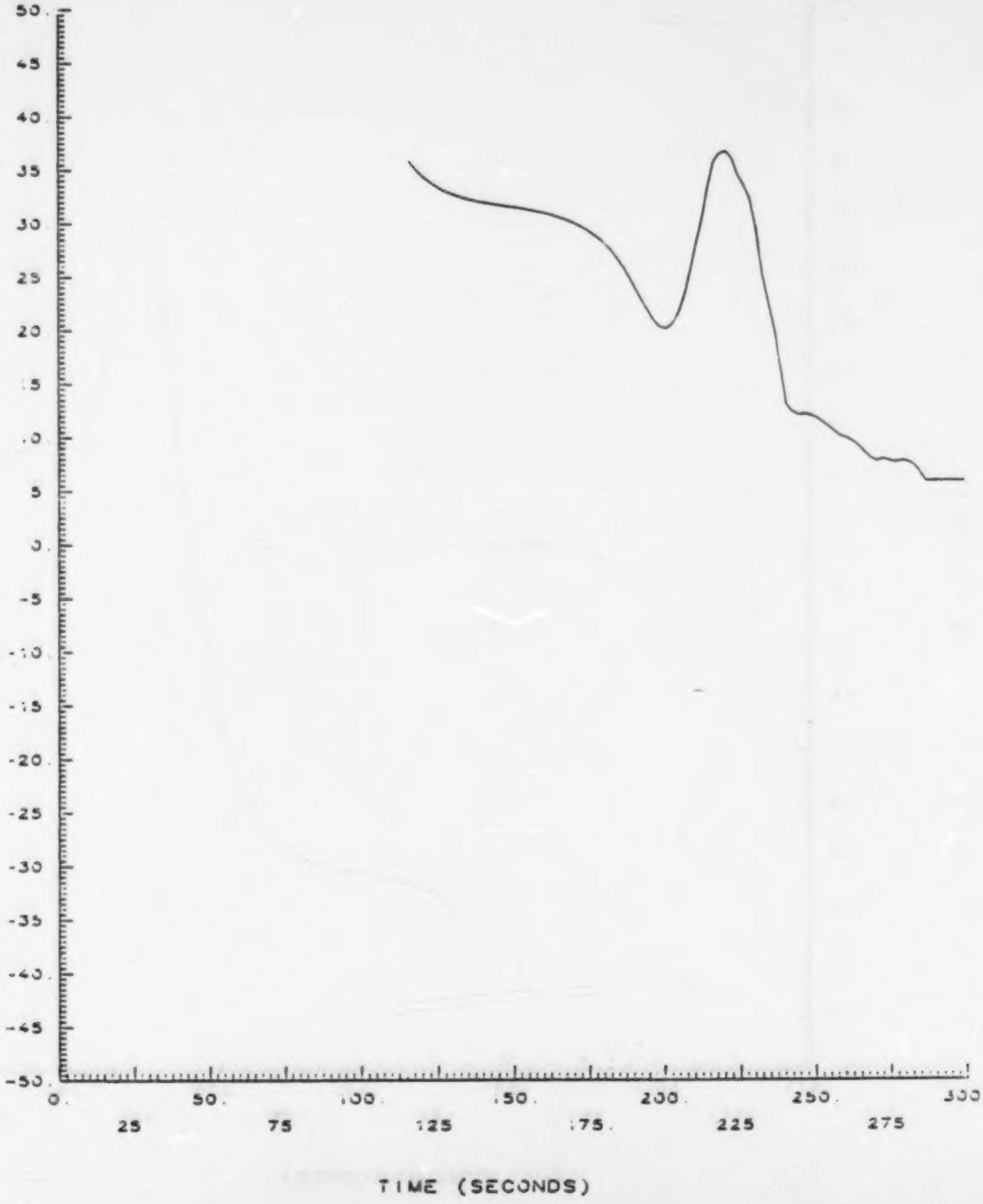


Figure 26

TABLE 4: ADDITIONAL IMPACT ESTIMATES FROM THE FAA AN/FPS-66 RADAR

NO.	N. LAT.	W. LONG
8	28°49'22"	80°00'31"
9	28°47'26"	80°04'35"
10	28°47'51"	80°01'01"
11	28°45'59"	80°01'28"
12	28°42'18"	79°59'10"
13	28°41'53"	79°57'21"
14	28°40'40"	79°59'13"
15	28°37'54"	80°03'26"
16	28°37'15"	79°57'11"
17	28°36'57"	80°01'02"
18	28°46'06"	80°00'21"

Uncertainty ellipse orientations = 120°
Semi-major Axes (nm) = 0.75
Semi-minor Axes (nm) = 0.25

GLOSSARY

AOS	Acquisition of Signal
ARTC	Air Route Traffic Control
BET	Best Estimate of Trajectory
CCAFS	Cape Canaveral Air Force Station
dBsm	DeciBels relative to one square meter
DPDE	Data Playback and Digitizing Equipment (Video)
ESMC	Eastern Space and Missile Center
ET	External Tank
ETR	Eastern Test Range
FAA	Federal Aviation Administration
IFLOT	Intermediate Focal Length Optical Tracker
IGOR	Intercept Ground Optical Recorder
KSC	Kennedy Space Center
LOS	Loss of Signal
LOV	Loss of Visibility
MCBR	Mobile C-Band Radar
MSFC	Marshall Space Flight Center
MIGOR	Mobile Intercept Ground Optical Recorder
NITE	N-Interval Trajectory Estimation Program
PDV	Peak Detected Video
PRF	Pulse Recurrence Frequency
RAE	Range/Azimuth/Elevation
RAPP	Computer Program 331, Radar Position Program
RCS	Radar Cross Section
ROTI	Recording Optical Tracking Instrument
RTI	Range/Time/Intensity (Video)
S/N	Signal-To-Noise Ratio
SRB	Solid Rocket Booster
TCAR	Computer Program 017, Tracking Camera Automatic Reduction
UCS	Universal Camera Site
WGS	World Geodetic System (ETR uses WGS-72)
WSMC	Western Space and Missile Center

APPENDIX A

ESMC Range Instrumentation

A.1 *General*

Instrumentation utilized by ESMC, which includes resources of other agencies, is summarized in Figure A-1.

A.2 *Tracking Radars*

The C-Band radars listed in Table A-1 are used for Range Safety purposes and for provided metric data to the Range User. All ESMC tracking radars are azimuth-elevation-range sensors which do not have provisions for range-doppler measurements. Each radar is equipped with a boresight TV camera and recorder to assist with calibration and mission support.

The FPQ-13, FPQ-14, and FPQ-15 radars are "On-Axis" types which utilize computer processing of receiver signals and tracking algorithms in order to enhance precision. In addition to metric data, On-Axis radars compute and record signature data (Signal/Noise and RCS) at full PRF rate of 160 Hertz. Radar 91.14 is equipped for on-site precording of receiver video, and Radar 0.14 receiver video is recorded at the Patrick Tech Lab DPDE facility.

The mobile MCBRs utilize an equipment van and a pedestal trailer. These radars can be positioned for most effective mission support in the CCAFS/KSC area or dispatched to remote locations such as Jupiter, Florida.

A.3 *Optics*

The optical instruments listed in Table A-2 collect metric data, comprised of azimuth and elevation measurements, and engineering sequential data which document mission events. Data are recorded on photographic film or video tape.

A.4 *Surveys*

The geodetic location of radar and optical sites are listed in Tables A-3 and A-4, respectively.

TABLE A-1: ESMC C-BAND TRACKING RADARS

Radar Designator	Radar Type	Site Location	Antenna Diameter (Meters)	Peak Power (MW)	Special Capabilities
19.17	MCBR	KSC	3.7	1.0	Mobile
1.17	MCBR	CCAFS	3.7	1.0	Mobile
1.16	FPS-16	CCAFS	3.7	1.0	
19.14	FPQ-14	KSC	8.8	2.5	On-Axis
0.14	FPQ-14	PAFB	8.8	2.5	On-Axis, Video Recorded at DPDE
3.13	FPQ-13	GBI	6.1	5.0	On-Axis
91.14	FPQ-14	ANT	8.8	2.5	On-Axis, Video Recorded on site
12.15	FPQ-15	ASC	8.5	5.0	On-Axis
12.18	TPQ-18(M)	ASC	8.8	2.5	On-Axis

Note: Radars are listed by latitude, north to south

TABLE A-2: ESMC OPTICAL INSTRUMENTS

Site Designator	Optics Type[1]	Site Location	Lens Focal Length (meters)	Film Size (mm)
470501	MIGOR[2]	Ponce de Leon	1.5	Video Tape
UCS-10	IFLOT	CCAFS	2.0	70
UCS-10	IFLOT	CCAFS	0.5	16
UCS-10	MIGOR	CCAFS	9.1	70
UCS-5	Contraves	CCAFS	1.5	Video Tape
UCS-6	Contraves	CCAFS	1.5	Video Tape
UCS-6	IFLOT	CCAFS	2.0	70
UCS-6	IFLOT	CCAFS	0.6	16
UCS-12	IFLOT[3]	CCAFS	2.0	70
UCS-15	IFLOT	CCAFS	2.0	70
UCS-15	IFLOT	CCAFS	0.5	16
UCS-8	Contraves	CCAFS	1.5	Video Tape
DSIF-71	Contraves	CCAFS	1.5	Video Tape
350601	ROTI	Cocoa Bch	5.1	Video Tape
000501	IGOR	PAFB	12.7	35
360601	ROTI	Melbourne Bch	10.2	70

NOTES: 1) All instruments except IFLOT are equipped with azimuth and elevation encoders.

2) The tracking scope (1 meter focal length) of the Ponce MIGOR is equipped with TV camera and recorder.

3) Located northeast of UCS-12 site.

4) Sites are listed by latitude, north to south

TABLE A-3: GEODETIC COORDINATES FOR ESMC C-BAND RADARS

		WGS-72 Survey		
Designation	Location	+ N. Latitude	+ E Longitude	Geodetic Height (Meters)
19.17	KSC	28°37'33.2213"	279°19'01.3468"	- 19.31
1.17	CCAFS	28°31'43.2797"	279°24'34.6546"	- 23.63
1.16	CCAFS	28°28'53.6479"	279°25'24.0130"	- 15.81
19.14	KSC	28°25'28.7859"	279°20'07.6130"	- 18.53
0.14	PAFB	28°13'34.8742"	279°24'02.0120"	- 14.94
3.13	GBI	26°36'56.0369"	281°39'07.3290"	- 15.30
91.14	ANT	17°08'36.9580"	298°12'26.3882"	+ 0.50
12.15	ASC	-7°54'24.0382"	345°35'50.4740"	+ 56.09
12.18	ASC	-7°58'21.4285"	345°35'55.0979"	+141.98

NOTE: Survey values refer to the center of rotation of the antenna

TABLE A-4: GEODETIC COORDINATES FOR ESMC OPTICAL SITES

		WGS-72 Survey		
Designation	Location	+ N. Latitude	+ E Longitude	Height (Meters)
470501	Ponce de Leon	29°04'01.0260"	279°05'12.7536"	-27.76
UCS-10	CCAFS	28°42'10.3466"	279°19'52.7071"	-23.38
UCS-5	CCAFS	28°38'38.7879"	279°20'03.2996"	-23.46
UCS-6	CCAFS	28°36'30.2236"	279°19'50.7814"	-23.42
UCS-12	CCAFS	28°36'05.5871"	279°24'38.7173"	-23.11
UCS-15	CCAFS	28°34'41.1888"	279°23'29.1711"	-26.14
UCS-8	CCAFS	28°33'28.9304"	279°24'44.2304"	-27.06
DSIF-71	CCAFS	28°28'45.8206"	279°26'01.2270"	-15.85
350601	Cocoa Beach	28°21'04.8019"	279°23'37.5607"	-19.44
000501	PAFB	28°13'37.1689"	279°24'00.8671"	-18.13
360601	Melbourne Bch	28°02'58.3949"	279°27'04.5644"	-15.60

ESMC
RANGE INSTRUMENTATION FACILITIES

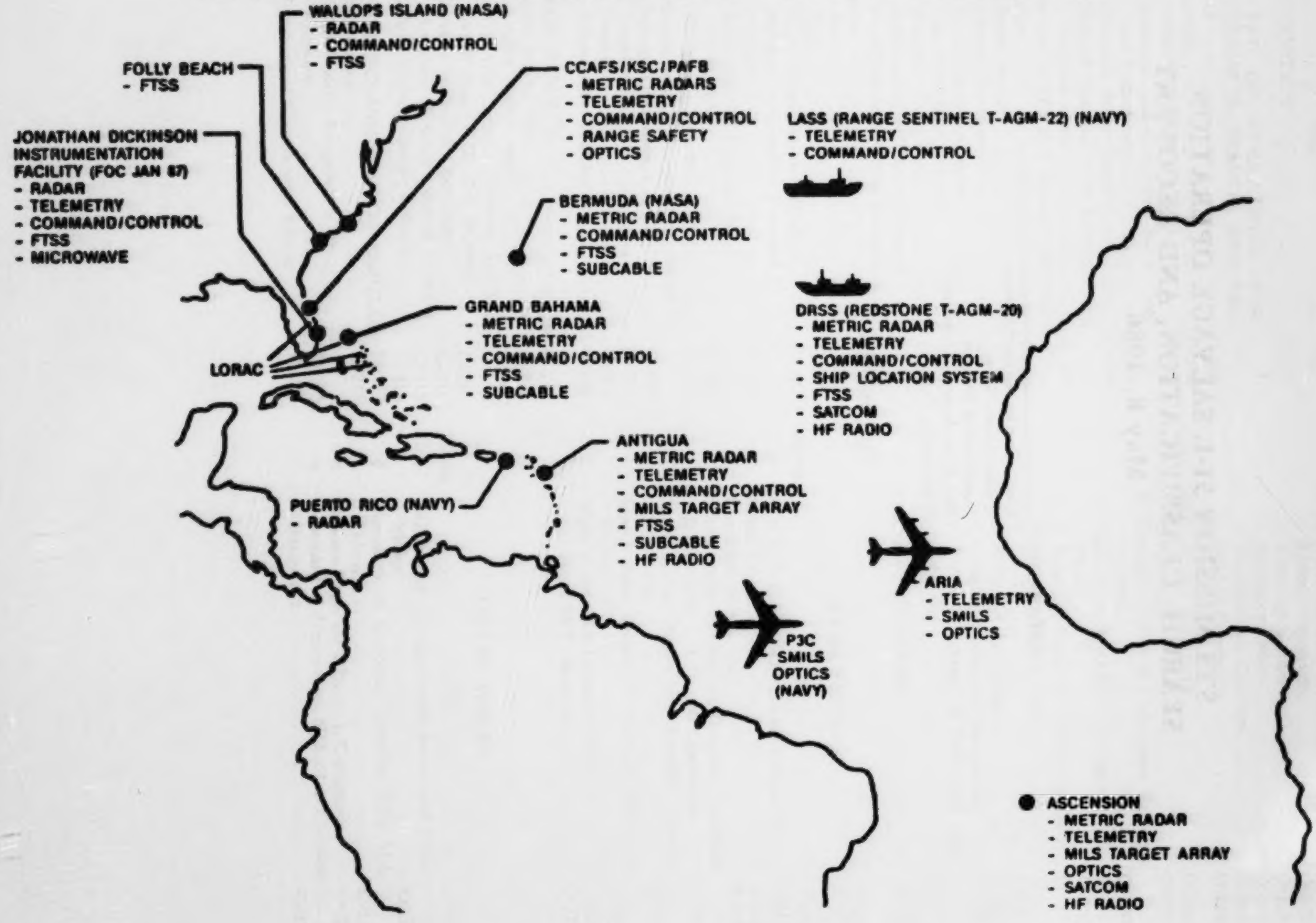

WALLOPS ISLAND (NASA)
- RADAR
- COMMAND/CONTROL
- FTSS
FOLLY BEACH
- FTSS
JONATHAN DICKINSON INSTRUMENTATION FACILITY (FOC JAN 87)
- RADAR
- TELEMETRY
- COMMAND/CONTROL
- FTSS
- MICROWAVE
CCAFS/KSC/PAFB
- METRIC RADARS
- TELEMETRY
- COMMAND/CONTROL
- RANGE SAFETY
- OPTICS
LASS (RANGE SENTINEL T-AGM-22) (NAVY)
- TELEMETRY
- COMMAND/CONTROL
BERMUDA (NASA)
- METRIC RADAR
- COMMAND/CONTROL
- FTSS
- SUBCABLE
GRAND BAHAMA
- METRIC RADAR
- TELEMETRY
- COMMAND/CONTROL
- FTSS
- SUBCABLE
LORAC
DRSS (REDSTONE T-AGM-20)
- METRIC RADAR
- TELEMETRY
- COMMAND/CONTROL
- SHIP LOCATION SYSTEM
- FTSS
- SATCOM
- HF RADIO
ANTIGUA
- METRIC RADAR
- TELEMETRY
- COMMAND/CONTROL
- MILS TARGET ARRAY
- FTSS
- SUBCABLE
- HF RADIO
PUERTO RICO (NAVY)
- RADAR
ARIA
- TELEMETRY
- SMILS
- OPTICS
P3C
SMILS
OPTICS
(NAVY)
ASCENSION
- METRIC RADAR
- TELEMETRY
- MILS TARGET ARRAY
- OPTICS
- SATCOM
- HF RADIO

Figure A-1

STS MISSION 51-L SALVAGE OPERATION
SEARCH, CLASSIFICATION, AND RECOVERY
May 8, 1986

PREPARED BY: ______________________________

Capt. Charles A. Bartholomew
United States Navy
Supervisor of Salvage
Naval Sea Systems Command
Washington, D.C.

ENCLOSURE 4

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STS 51-L SALVAGE OPERATION SEARCH, CLASSIFICATION, AND RECOVERY

I. *INTRODUCTION*

The U.S. Navy Supervisor of Salvage (SUPSALV) has been involved with the salvage of objects which require location, identification, and recovery from the ocean floor over the history of U.S. Navy salvage. Numerous aircraft, ships, and weapons systems components have required recovery for humanitarian, accident investigation, and security reasons.

Over the history of the Space Shuttle Program, the National Aeronautics and Space Administration (NASA) and SUPSALV have worked together, specifically in the areas of Solid Rocket Booster (SRB) recovery procedures and the identification of ships for SRB recovery operations. During the recent years of the NASA Space Shuttle Program, NASA and SUPSALV personnel have established a solid working relationship and negotiated formal Memoranda of Agreement definitizing this relationship.

Because of SUPSALV's experiences in salvage operations, ability to deploy both military and commercial assets for this effort, and developed working relationships with NASA, the Supervisor of Salvage was selected to head the Space Transportation System (STS) Mission 51-L (hereafter referred to as STS 51-L) Salvage Operation. Therefore, On January 31, 1986, at NASA's request, the Department of Defense Manager for Space Transportation System Contingency Support Operations (DDMS) requested U.S. Navy assistance from the Chief of Naval Operations (CNO). CNO, in turn, tasked SUPSALV's parent command (Commander, Naval Sea Systems Command) to undertake the STS 51-L salvage, mission and requested that Commander-in-Chief, U.S. Atlantic Fleet, provide support as necessary.

The following sections detail the salvage concepts employed, assets utilized, problems encountered, and results obtained during the course of the salvage operation. The primary mission of the STS 51-L Salvage Operation, to recover critical pieces for determination of mishap cause, has been achieved. Deep water salvage operations were terminated on May 1, 1986 and supporting assets demobilized. Ongoing salvage operations involving the recovery of high-interest debris in shallow water areas are not related to the mishap cause. This report documents events through May 1, 1986.

II. *CONCEPTS OF OPERATIONS FOR UNDERWATER SEARCH AND SALVAGE*

The planning for use and employment of assets for an underwater salvage operation of this complexity and magnitude are dependent upon a continually changing set of contact data, priorities, and environmental conditions. Collected data, priority establishment, and environmental conditions are the primary planning inputs which determine when and how available assets can be most effectively utilized. The STS 51-L Mishap underwater salvage effort consisted of three major overlapping phases: search, contact classification, and recovery. These phases were conducted concurrently due to the enormous scope of the total search operation and the time-critical requirement to recover key portions of the STS 51-L flight hardware for determination of accident cause. Contact information obtained during classification and recovery phases markedly altered search area and contact classification/recovery priorities. This section addresses the concept of operations for conducting the mission search, contact classification, and recovery phases of the salvage operation. Execution details for each phase are addressed in Sections III, IV, and V, respectively, of this report.

A. *Planning*

This paragraph provides an overview of the planning inputs and concepts involved with the search and salvage operations.

1. *Defined Search Area.*

(a) Initially based on available data obtained from:

(1) Eastern Space and Missile Center (ESMC) tracking radars.

(2) ESMC optical tracks.

(3) Federal Aviation Administration (FAA) radar information.

(4) Visual sightings reported by aircraft in area during STS 51-L launch and immediately after launch mishap.

(5) Location of floating STS 51-L debris.

(b) Subsequently revised based on collected data from:

(1) Side scanning sonar contacts.

(2) Identified STS 51-L debris

(3) Additional radar and optical tracking data.

2. *Collected and Correlated Sonar Contact Information.*

(a) Contact number.

(b) Date contact found.

(c) Contact location (Latitude and Longitude).

(d) Contact size.

(e) Contact bottom orientation (debris field).

(f) Contact water depth.

(g) Contact correlation with other available data and information.

(h) Contact description.

3. *Classified Sonar Contacts.*

(a) Contacts, evaluated as probable STS 51-L debris, prioritized by sonar contact strength and geographic location factors to determine order of subsequent investigation.

(b) Contact classification after visual verification (e.g., divers, photographs, or video).

4. *Defined Contacts to be Recovered and Assigned Assets.*

(a) Contact classification as Orbiter, Payload, External Tank, or SRB.

(b) Salvage assets assigned by Supervisor of Salvage (SUPSALV) per NASA priorities.

B. *Concepts of STS 51-L Salvage Operations Plan*

1. *Sonar Search*

Conducted wide area search using side scanning sonar to locate contacts within the defined search areas. Sonar scan width was 300 meters wide (150 meters per side) with 135-meter search line spacing to provide effective bottom area coverage with 165-meter (122 percent) overlapping of sonar coverage. Due to strong northern Gulf Stream currents existent in the eastern portions of the search area, ships conducted search lines in a southerly direction only. Although this involved additional repositioning time for conducting subsequent passes, it was necessary to ensure stability of the towed sonar "fish" in the strong currents and to achieve a consistent "fish" speed over the bottom in the 2- to 4-knot range. As current conditions permitted (i.e., less than 2.0 knots), search lines were conducted in both north and south directions.

2. *Contact Database*

Compiled a data base of contacts identified within the search area using an HP-9000 computer located on shore at the Supervisor of Salvage Command Post.

3. *Sonar Contact Analysis*

Analyzed sonar data based on characteristics of the sonar trace and location relative to known or suspected STS 51-L pieces. A graded list of contacts to be verified was developed from this data.

4. *Classification of Contacts*

In order of NASA-assigned priorities, conducted positive identification and classification of sonar contacts using the most effective available assets (i.e., divers, Remotely Operated Vehicles (ROV's), Manned Submersibles).

5. *Recovery Priorities*

Contacts prioritized by NASA were as follows:

(a) Right Solid Rocket Booster (SRB).

(b) Orbiter, Crew Compartment.

(c) Payload: Tracking and Data Relay Satellite System (TDRSS), and Inertial Upper Stage (IUS).

(d) Left SRB.

(e) Specified Orbiter Components.

(f) External Tank (ET).

6. *Employment of Recovery Assets*

SUPSALV assigned assets to conduct recovery of contacts in accordance with overall NASA priorities.

C. *Flow of Data and Record Keeping*

1. Recorded data (e.g, video, sonar traces, photographs) obtained by salvage operation vessels were transferred to the Supervisor of Salvage Command Post via support craft designated for the purpose.

2. Daily situation reports (SITREPS) were transmitted to SUPSALV via radio by all vessels at 0800, 1200, and 1600 hours, local time.

3. The following records and reports were maintained by the Supervisor of Salvage:

(a) Daily SITREPS.
(b) Master Event Log for STS 51-L Operations.
(c) Sonar traces.
(d) STS 51-L Salvage Operations Search and Contact Plot.
(e) Sonar Contact Summary Evaluation Reports.
(f) Search Line and Contact Summary Reports.
(g) Search Line Log (cumulative).
(h) Field Notes on STS 51-L Salvage Operations.
(i) Video tapes of contacts.
(j) Still photographs of contacts.
(k) Voice Radio Transmissions Log.

D. *Assets*

1. Ashore (Supervisor of Salvage Command Post):

(a) Supervisor of Salvage staff personnel.

(b) Three vans for command, administrative, and technical evaluation personnel.

(c) One HP-9000 Model 520 computer and two HP-7580A Plotters for tracking/plotting search area contacts and overall data management.

(d) Ship-to-shore communications (UHF/VHF/telephone to MARISAT-capable ships).

(e) Video system for reviewing and copying video film.

(f) Technical personnel for evaluation of sonar data and maintenance of sonar data records and video.

2. *Ships*: (for more detailed information, see Table 1, Search and Salvage Vessel Assets and Capabilities):

(a) NASA
  (1) *M/V Liberty Star
  (2) M/V Independence
  (3) M/V Freedom Star
(b) U.S. Air Force (ESMC)
  (1) LCU (USAF Range Salvage Vessel, C115-1925)
(c) U.S. Navy
  (1) USS Preserve (ARS 8)
  (2) USS Opportune (ARS 41)
  (3) USS Sunbird (ASR 15)
  (4) NR-1
  (5) USS Kittiwake (ASR 13)
(d) SUPSALV
  (1) M/V Stena Workhorse (Tracor)
  (2) *R/V Seward Johnson (Eastport/Harbor Branch Foundation)
  (3) R/V Edwin Link (Eastport/Habor Branch Foundation).
  (4) M/V G.W. Pierce II (Tracor)
  (5) M/V Paul Langevin III (Tracor)
  (6) M/V Eliminator (Tracor/Canaveral Marina)
  (7) M/V Pelican Princess (Tracor/Canaveral Marina)

3. *ROV's Provided by SUPSALV* (for more detailed information see Table 1, refer to ship noted):

(a) Navy Deep Drone (M/V Independence)
(b) Gemini (M/V Stena Workhorse)
(c) Scorpi (USS Opportune)

4. *Manned Submersibles Provided by SUPSALV* (for more detailed information, see Table 1, refer to ship noted):

(a) Sea Link I (R/V Edwin Link)
(b) Sea Link II (R/V Seward Johnson)

5. *Sonar Systems Provided by SUPSALV*:

Side Scanning Sonar—Surface vessels used side scanning sonar to conduct search efforts. Physically, a side scanning sonar is a cylindrical transducer assembly 4 inches in diameter and 4 feet in length, weighing 50 pounds. The sonar transducers emit acoustic signals as the side scanning sonar "fish" is towed through the water. The optimum towing altitude is 15 meters above the bottom when utilizing the 150-meter scale to achieve a 300-meter scan width. When the transmitted acoustic signals strike an object on the bottom of the ocean they are reflected back to a receiving transducer. Signal strength is directly related to the size, shape, and materials of objects reflecting the signals. A strip chart recorder, located on the tow ship, processes signals into a graphic representation which can be correlated to geographical locations with respect to the ship's position.

6. *Navigation Systems*:

(a) SUPSALV

(1) *GPS/LORAN-C* (Global Positioning System/Long Range Aid to Navigation, Version C)—GPS/LORAN-C, multi-user navigation system, was the primary navigation system used by the vessels conducting search, classification, and recovery operations. This navigation system consists of a Magnavox GPS satellite positioning receiver, a Simrad LORAN-C receiver, and a Hewlett Packard computer/plotter system. The GPS receiver is used to position the vessels during periods when an acceptable GPS satellite signal can be received. For the STS 51-L search area, this period averages 10 to 12 hours per day. During periods of acceptable satellite signals, simultaneous GPS and LORAN-C fixes are taken and compared by the computer. Correction factors are applied to the LORAN-C readings by the navigational computer so that both systems display the exact same position. This comparison is performed internally within the Hewlett Packard computer whenever inputs from both navigation systems are available. When GPS satellite signals are not being received, the corrected LORAN-C readings are used to position the vessel. GPS/LORAN-C system accuracy ranges from 10 to 25 meters which was suitable for the operations being conducted (reference Section III.D.1). A plotter unit connected to the navigation computer was used to plot all navigational fixes taken during operations.

(2) *Pingers*—Pingers are small acoustic transmitters (37.5 khz) which are used to mark objects for future location. The pinger transmits an underwater acoustic signal which is detectable by shipboard and underwater vehicle transducers, and is used by ships and vehicles to relocate the object by tracking the bearing to the pinger signals. Pingers used for STS 51-L salvage operations have a minimun 30-day operating period, limited by battery life.

(b) U.S. Air Force (ESMC)

LORAC-A (Long Range Accuracy, Version A)—LORAC-A is a local radio navigation system operated by the Eastern Space and Missile Center (ESMC). The LORAC-A system was originally installed in 1961 to support Pershing missile launches. The system is based on continuous wave (CW) phase comparison and has a reported accuracy of 15 meters within the STS 51-L search areas. Contact positions identified using LORAC-A navigation were relocated during classification and salvage phases of the salvage operation using GPS/LORAN-C systems, thereby validating the accuracy of the LORAN-A system. During STS 51-L search and salvage operations the USAF range boat (LCU) utilized LORAC-A.

E. *Selection and Employment of Assets for Salvage Operations*

1. *Introduction*

The magnitude of the search effort combined with the wide range of water depths, currents, visibility, bottom conditions, and sea states required the selection of various types of search and recovery assets. No single vessel, vehicle, or system is ideally suited for the variety of conditions expected during operations. Therefore, the selection of assets for this operation had to span

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*M/V: Motor Vessel
*R/V: Research Vessel
*ARS: Auxiliary Rescue and Salvage
*ARS: Auxiliary Submarine Rescue

Table 1. Search and Salvage Vessel Assets and Capabilities

PLATFORM	SHIP SPECIFICATIONS	SEARCH/SALVAGE ASSETS
FREEDOM STAR (NASA) *Searching 2/8/86 - Present	Length: 176 Feet Beam: 37 Feet Draft: 12 Feet Clear Deck Space: 2420 Ft^2 Max Speed: 17 Knots	GPS/LORAN-C NAVIGATION ** Side Scanning Sonar **: -- Max Depth of 700 Feet Through 4/1/86 -- Max Depth of 3,000 Feet After 4/1/86
LIBERTY STAR (NASA) *Searching 2/8/86 - Present	Length: 176 Feet Beam: 37 Feet Draft: 12 Feet Clear Deck Space: 2420 Ft^2 Max Speed: 17 Knots	GPS/LORAN-C NAVIGATION ** Side Scanning Sonar **: -- Max Depth of 3,000 Feet
INDEPENDENCE (NASA) *Classification *Recovery 2/8/86 - Present	Length: 199 Feet Beam: 40 Feet Draft: 15 Feet Clear Deck Space: 4200 Ft^2 Max Speed: 13 Knots Lifting Capacity: 4.5 Tons	GPS/LORAN-C NAVIGATION ** DEEP DRONE **: -- Unmanned ROV -- Max Depth 6,000 Feet -- Sonar, High Resolution 360 DEG, for contact localization -- Video Cameras (3) -- Still Photo Camera -- Two Manipulators -- Duration limited only by surface support platform
LCU--RANGE BOAT (USAF) *Searching *Classification *Recovery 2/8/86 - 4/7/86	Length: 126 Feet Beam: 24 Feet Draft: 6 Feet Clear Deck Space: 1400 Ft^2 Max Speed: 8 Knots Lifting Capacity: 10 Tons	LORAC (A) NAVIGATION SCANNING SONAR, MESOTECH**: -- Max Depth 200 Feet DIVERS (14): -- Air to 100 Feet
USS PRESERVER (US NAVY) *Classification *Recovery 2/8/86 - 4/11/86	Length: 201 Feet Beam: 43 Feet Draft: 13 Feet Clear Deck Space: 3230 Ft^2 Max Speed: 14.8 Knots Lifting Capacity: -- 8 Tons Forward -- 10 Tons Aft Recompression Chamber Air Diving Support System	GPS/LORAN-C NAVIGATION ** DIVERS (22): -- Air Diving to 190 Feet -- Diver Held Video Camera -- Diver Held 35mm Camera

* Vessel Employment Phases
** SUPSALV Supplied Assets

Table 1. Search and Salvage Vessel Assets and Capabilities

PLATFORM	SHIP SPECIFICATIONS	SEARCH/SALVAGE ASSETS
USS OPPORTUNE (US NAVY) *Classification *Recovery 4/5/86 - Present	Length: 214 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3440 Ft^2 Max Speed: 15.0 Knots Lifting Capacity: -- 20 Tons Forward -- 12 Tons Aft Recompression Chamber Air Diving Support System	GPS/LORAN-C NAVIGATION ** SCANNING SONAR, MESOTECH **: -- Max Depth 200 Feet DIVERS (22): -- Air Diving to 190 Feet -- Diver Held Video Camera -- Diver Held 35mm Camera SCORPI **: -- Employed 4/22/86-Present -- Unmanned ROV -- Max Depth 3000 Feet -- Forward Speed 4 Knots -- Sonar Range 4 to 400 Feet -- Video Cameras (2) -- Still Photo Camera -- One Manipulator
USS SUNBIRD (US NAVY) *Classification *Recovery *NR-1 Support 2/20/86 - 3/18/86 3/31/86 - 4/17/86	Length: 252 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3440 Ft^2 Max Speed: 15 Knots Lifting Capacity: 10 Tons Recompression Chamber Diving Support Capability: -- Air and Mixed Gas (HEOX) Submarine Rescue Capability	GPS/LORAN-C NAVIGATION ** SCANNING SONAR, MESOTECH **: -- Max Depth of 200 Feet DIVERS(24): -- Air Diving to 190 Feet -- HEOX Diving to 300 Feet -- Diver Held Video Camera -- Diver Held 35mm Camera
NR-1 RESEARCH SUB (US NAVY) *Wide Area Search *Classification 2/20/86 - 3/18/86 3/31/86 - 4/17/86	Length: 137 Feet Beam: 16 Feet Draft: 15 Feet Clear Deck Space: N/A Max Speed: -- 4.5 Knots Surface -- 3.5 Knots Submerged Sample Collection Baskets,2 Lifting Capacity: -- Manipulator, 1,000 lbs -- Object Recovery System, 500 lbs	NAVIGATION: -- Dead Reckoning w/Digital Computer (Accuracy 1.5% Distance Traveled) -- 4 Deployable Transponders (Used to mark contacts and to update location) Side Looking Sonar: -- 600 Feet Search Width With 1 Foot Resolution -- 2,400 Feet Search Width With 4 Feet Resolution Forward Looking Sonar: -- 3 to 1,500 Yard Range -- 1 to 30 Yards Resolution Sub-Bottom Profiler Eleven Video Cameras Four Still Photo Cameras

* Vessel Employment Phases
** SUPSALV Supplied Assets

Table 1. Search and Salvage Vessel Assets and Capabilities

PLATFORM	SHIP SPECIFICATIONS	SEARCH/SALVAGE ASSETS
USS KITTIWAKE (US NAVY) *Recovery 4/11/86 - 4/22/86	Length: 252 Feet Beam: 44 Feet Draft: 16 Feet Clear Deck Space: 3440 Ft^2 Max Speed: 15 Knots Lifting Capacity: 10 Tons Recompression Chamber Diving Support Capability: -- Air and Mixed Gas (HEOX) Submarine Rescue Capability	GPS/LORAN-C NAVIGATION ** SCANNING SONAR, MESOTECH **: -- Max Depth of 200 Feet DIVERS(24): -- Air Diving to 190 Feet -- HEOX Diving to 300 Feet -- Diver Held Video Camera -- Diver Held 35mm Camera
STENA WORKHORSE (SUPSALV) *Classification *Recovery 2/28/86 - 5/1/86	Length: 320 Feet Beam: 61 Feet Draft: 20 Feet Clear Deck Space: 6030 Ft^2 Max Speed: 17 Knots Lifting Capacity: 100 Tons Dynamic Positioning System Helideck Hospital, 2-Bed Saturation Diving System -- 1,500 Feet	GPS/LORAN-C NAVIGATION ** GEMINI **: -- Unmanned ROV -- Max Depth 5,000 Feet -- Forward Speed 3 Kts -- Sonar Range 4 to 200 Feet -- Video Cameras (3) -- Still Photo Cameras (3) -- Two Manipulators With 1,500 lbs Lift Capacity
SEWARD JOHNSON (SUPSALV) *Classification *Recovery 2/21/86 - 4/19/86	Length: 176 Feet Beam: 36 Feet Draft: 12 Feet Clear Deck Space: 3120 Ft^2 Max Speed: 14 Knots Lifting Capacity: 5 Tons Sub Handling System:18 Tons Ship Stabilizing System Precision Station-Keeping: -- 360 DEG Bow & Stern Thrusters	GPS/LORAN-C NAVIGATION ** SEALINK II **: -- Manned Submersible -- Max Depth 2,640 Feet -- Sonar -- Video Cameras (3) -- Manipulator
EDWIN LINK (SUPSALV) *Classification *Recovery 3/27/86 - 5/1/86	Length: 123 Feet Beam: 27 Feet Draft: 11.5 Feet Clear Deck Space: 1440 Ft^2 Max Speed: 13 Knots Lifting Capacity: 5 Tons Sub Handling System:12 Tons Decompression Chamber: -- Max Depth 750 Feet Ship Stabilizing System Bow Thruster	GPS/LORAN-C NAVIGATION ** SEA LINK I **: -- Manned Submersible -- Max Depth 2,640 Feet -- Sonar Range, 2,000 Feet -- Video Cameras (3) -- Manipulator

* Vessel Employment Phases

** SUPSALV Supplied Assets

Table 1. Search and Salvage Vessel Assets and Capabilities

PLATFORM	SHIP SPECIFICATIONS	SEARCH/SALVAGE ASSETS
G.W. PIERCE II (SUPSALV) *Searching 2/25/86 - 4/1/86 *Recovery 4/1/86 - 4/19/86	Length: 158 Beam: 30 Feet Draft: 9 Feet Clear Deck Space: 2390 Ft^2 Max Speed: 10 Knots Lifting Capacity: 10 Tons	GPS/LORAN-C NAVIGATION ** Side Scanning Sonar **: -- Max Depth 3,000 Feet Through 4/1/86 DIVERS (12): -- Employed 4/1/86-5/1/86 -- Diver Held Video Camera -- Diver Held 35mm Camera
PAUL LANGEVIN III (SUPSALV) *Searching 3/13/86 - Present	Length: 144 Feet Beam: 29 Feet Draft: 9 Feet Clear Deck Space: 2600 Ft^2 Max Speed: 13 Knots Lifting Capacity: 10 Tons	GPS/LORAN-C NAVIGATION ** Side Scanning Sonar **: -- Max Depth 500 Feet
ELIMINATOR (SUPSALV) *Support Craft for Personnel and Cargo X-fer	Length: 70 Feet Beam: 19 Feet Draft: 5 Feet Clear Deck Space: 700 Ft^2 Max Speed: 20 Knots	LORAN-C NAVIGATION
PELICAN PRINCESS (SUPSALV) *Support Craft for Personnel and Cargo X-fer	Length: 90 Feet Beam: 26 Feet Draft: 6 Feet Clear Deck Space: 950 Ft^2 Max Speed: 18 Knots	LORAN-C NAVIGATION

* Vessel Employment Phases
** SUPSALV Supplied Assets

the total range of conditions found in the search area. Once the assets were available on scene, the specific employment of ships, vehicles, personnel, and equipment was detemined by the SUPSALV on-scene commander based on the specific task to be performed (i.e., search, classification, or recovery), contact location within the search area, and the associated environmental conditions. The following sections describe the characteristics of the assets selected for this operation and the factors involved in employment decisions.

2. *Vessels*

NASA and U.S. Air Force (ESMC) vessels were selected to support underwater search and salvage operations for the following reasons:

(a) Already on scene and familiar with local environmental conditions.

(b) Vessels had good positioning and maneuvering ability and large, clear deck space.

(c) Vessels were already under NASA and ESMC contracts and, therefore, immediately available with known costs.

Navy vessels were selected based on availability and salvage and search capabilities. Auxiliary Rescue and Salvage (ARS) ships were selected for salvage and diving capabilities. Auxiliary Submarine Rescue (ASR) ships were selected for diving capability, which included mixed gas diving to 300 feet, and ability to function as support ships for the NR-1 submerged operations. The NR-1, a Navy research submarine, was selected for her unique wide area search capability, unlimited underwater duration, video/photographic documentation systems, and ability to get below currents and work on the ocean floor unhampered by umbilical drag.

Commercial vessels under SUPSALV contract were selected based on search and deep ocean salvage capabilities as follows:

(a) M/V Stena Workhorse: ability to work in high sea states, ability to maintain precise locations with a Dynamic Positioning System, familiarity in conducting deep ocean ROV operations, large clear deck area, lift capability, and saturation diving capability (1,500 feet), if needed.

(b) M/V Seward Johnson: precise maneuvering ability, large clear deck area, expertise in operating manned submersibles (e.g., Sea Link II), and lift capacity.

(c) M/V Edwin Link: lift capacity, large clear deck area, precise maneuvering ability, and expertise in operating manned submersibles (e.g., Sea Link I).

(d) M/V Paul Langevin III (PL-3): diving support capability, large clear deck area, suitability for conducting underwater search operations, and lift capacity.

(e) M/V G.W. Pierce II: diving support capability, large clear deck area, and suitability for conducting underwater search operations.

(f) M/V Eliminator and M/V Pelican Princess: Suitability as support craft for conducting personnel and cargo transfers.

3. *Submersible Vehicles*

The selection of submersible vehicles for STS 51-L operations proved difficult for two primany reasons:

(a) Depth of operations in eastern half of search area.

(b) Velocity of Gulf Stream currents.

When environmental conditions permit, ROV's are normally preferred over manned submersibles because of their around-the-clock operating capability. ROV's also have a greater lift capacity than manned submersibles. Numerous ROV's are available which can exceed the water depths encountered in this operation. However, most ROV's can only operate in a maximum of ½-knot current at depths greater than 1,000 feet because the power requirements necessary to overcome the effects of current drag on the ship-to-vehicle support cable increase markedly with depth. Therefore, two ROV systems were initially selected to assist in the operation. The U.S. Navy's Deep Drone was assigned shallow, low current areas, and a Gemini system was utilized for the high current, deep areas.

Unlike the Deep Drone, which uses a direct ship-to-vehicle cable, the Gemini can be used with a tether management system (TMS). With a TMS, one ROV support cable connects from the ship to a bottom attachment unit (BAU), and a second cable connects from the BAU to the ROV. This was a significant feature since the heavy TMS BAU could be lowered to a position near the bottom which allowed the Gemini to only pull around a short tether in the lower bottom currents. Gemini, equipped with two 40-hp hydraulic pumps, was able to work in areas with as much as 4-5 knots of surface current.

A third ROV, SCORPI, was employed starting April 22, 1986. This ROV was chosen to expedite contact classification efforts in shallow water areas with numerous contacts.

Manned submersibles were selected for STS 51-L salvage operations because 1) they did not require a tether to a surface support vessel which minimized current drag from the Gulf Stream, and 2) for real-time on-site observer capability which allowed NASA technical personnel to view debris directly as submersible occupants and, thus, expedited contact classification efforts. Two manned submersibles owned by the Harbor Branch Foundation were used for STS 51-L salvage operations: Sea Link I, operating from the R/V Edwin link; and Sea Link II, operating from the R/V Seward Johnson. Both of these manned submersibles operated effectively at all water depths involved in the salvage operation. The significant limitations of these systems were launch/recovery sea states (maximum 6-8 feet) and reduced bottom time (maximum 6-8 hours/day relative to ROV's.

Table 1, Search and Recovery Vessel Assets and Capabilities, summarizes the overall assets available for this operation.

Figure 1, STS 51-L Salvage Operation Organization, shows the command organization relationships and primary employment of assets.

III. *SEARCH RESULTS*

A. *Initial Search Area*

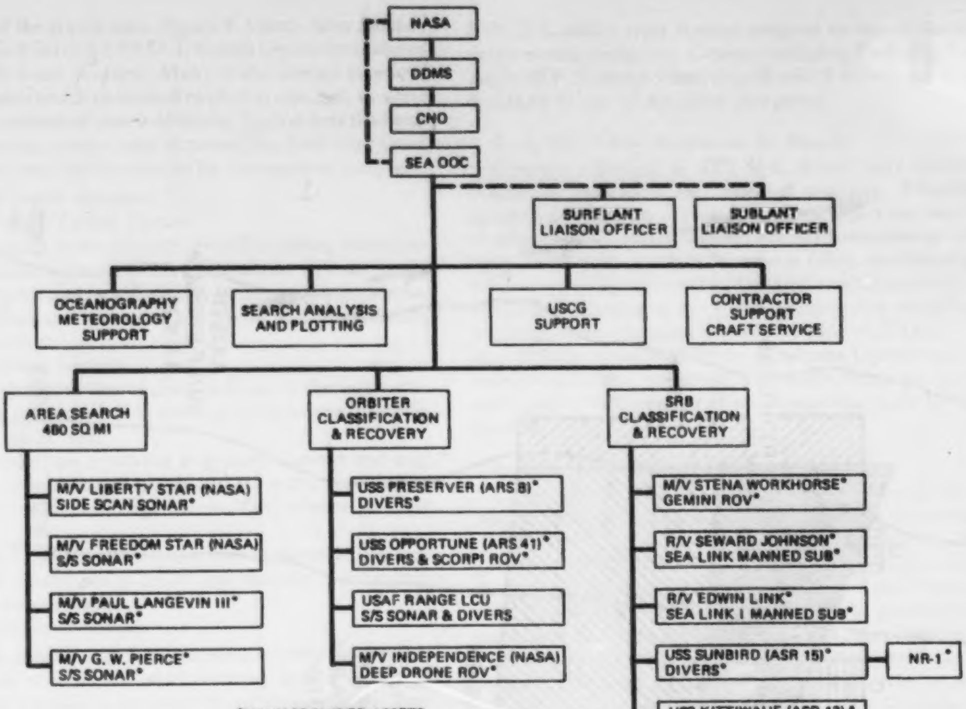
The initial search area established by SUPSALV was a parallelogram measuring 10 by 25 nautical miles as shown in Figure 2. This area was chosen to be 5 nautical miles on each side of the azimuth along which initial radar tracking analysis showed to be the major STS 51-L debris impact points. The water depths in the search area ranged from 70 feet of sea water (fsw) to approximately 1,200 fsw. This initial search area was west of the main axis of the Gulf Stream but still within the outermost boundaries of the stream. Gulf Stream currents were a significant handicap in conducting search operations.

B. *Expanded Search Area*

The initial search area was incrementally enlarged as the optical and radar data was refined and sonar contacts were classified by divers, ROV's, and manned submersibles. A right Solid Rocket Booster (SRB) debris field was found north of the initial search area and a debris field containing portions of the left SRB was located just inside the eastern edge of the initial search area. Further analysis of trajectory information and the location of both SRB debris fields led to the expansion of the initial search area (Area A) to approximately 420 square nautical miles by adding Search Area B (reference Figure 3). As the search progressed, other areas of STS 51-L debris and protential areas for debris were identified and expanded the search area to 480 square nautical miles. The NR-1 conducted a large area search (3 × 20 nm) east of Area A. No SRB debris was identified in this area and, therefore, provided high confidence that the original search area's eastern border bounded all SRB debris.

C. *Search Area Contact Summary and Location of Major STS 51-L Mission Sections*

Through May 1, 1986, a total of 691 contacts were identified using the side scanning sonars. The search effort in the bounded area, as shown in Figure 3, Expanded Search Area; is complete. The right and left SRB debris fields are located, as shown, on


NASA
DDMS
CNO
SEA OOC
SURFLANT LIAISON OFFICER
SUBLANT LIAISON OFFICER
OCEANOGRAPHY METEOROLOGY SUPPORT
SEARCH ANALYSIS AND PLOTTING
USCG SUPPORT
CONTRACTOR SUPPORT CRAFT SERVICE
AREA SEARCH 480 SQ MI
ORBITER CLASSIFICATION & RECOVERY
SRB CLASSIFICATION & RECOVERY
M/V LIBERTY STAR (NASA) SIDE SCAN SONAR*
M/V FREEDOM STAR (NASA) S/S SONAR*
M/V PAUL LANGEVIN III* S/S SONAR*
M/V G. W. PIERCE* S/S SONAR*
USS PRESERVER (ARS 8)* DIVERS*
USS OPPORTUNE (ARS 41)* DIVERS & SCORPI ROV*
USAF RANGE LCU S/S SONAR & DIVERS
M/V INDEPENDENCE (NASA) DEEP DRONE ROV*
M/V STENA WORKHORSE* GEMINI ROV*
R/V SEWARD JOHNSON* SEA LINK MANNED SUB*
R/V EDWIN LINK* SEA LINK I MANNED SUB*
USS SUNBIRD (ASR 15)* DIVERS*
NR-1*
USS KITTIWAUE (ASR 13)* DIVERS*

*NAVY PROVIDED ASSETS
ALL ASSETS ARE NAVY CONTROLLED

Figure 1. STS 51-L Salvage Operation Organization

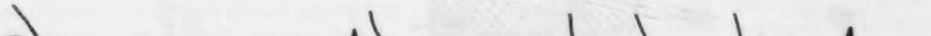

STS 51-L LAUNCH SITE
STS 51-L INITIAL IMPACT AZIMUTH
10 NM
25 NM
INITIAL SEARCH AREA (250 SQ NM)
INNER EDGE OF GULF STREAM 1-1.5 KTS
AXIS OF GULF STREAM 4-5 KTS
100
600
1200
1800

Figure 2. Initial Search Area

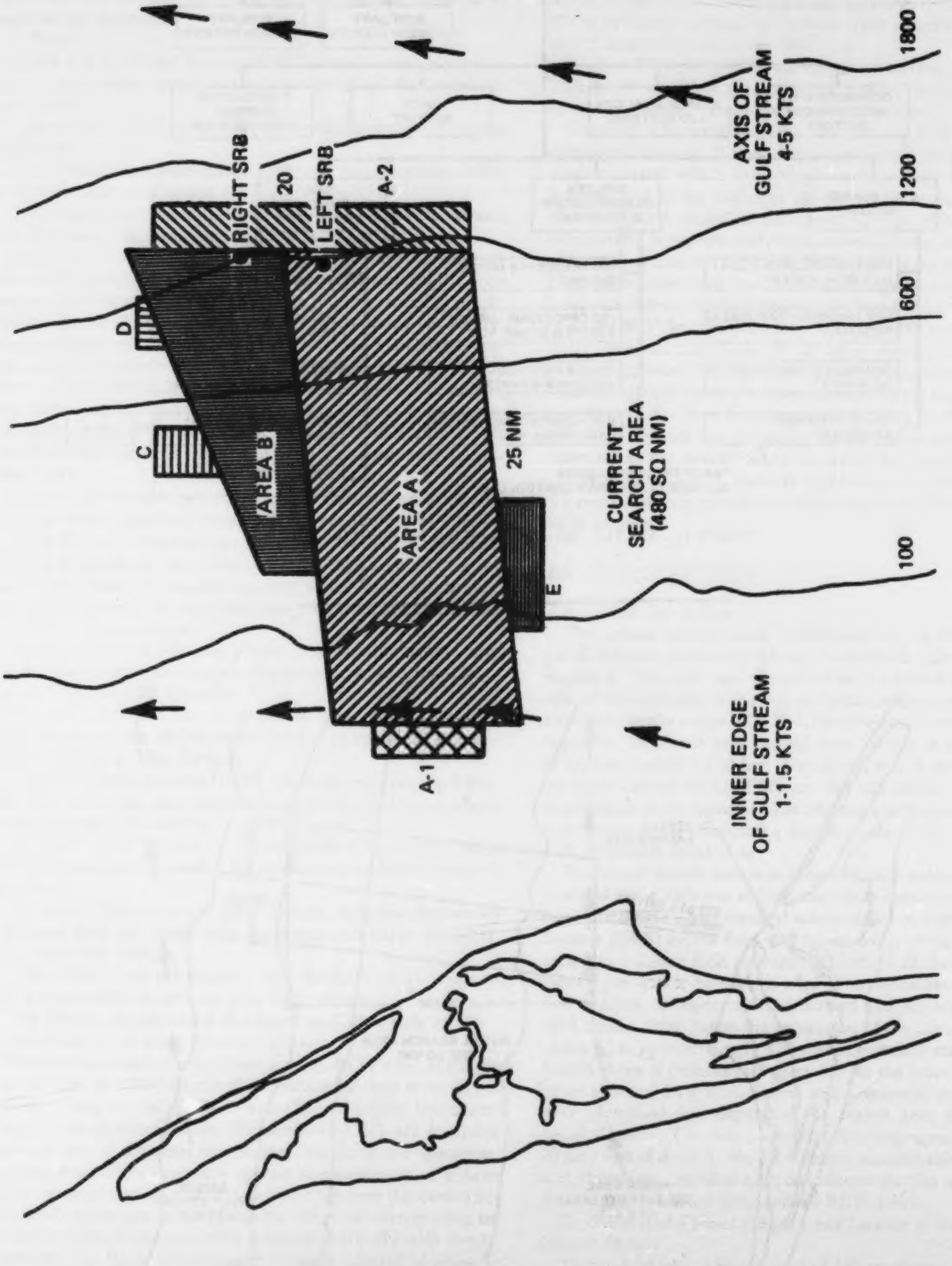

RIGHT SRB
20
LEFT SRB
A-2
D
C
AREA B
AREA A
25 NM
CURRENT SEARCH AREA (480 SQ NM)
E
A-1
INNER EDGE OF GULF STREAM 1-1.5 KTS
100
600
1200
1800
AXIS OF GULF STREAM 4-5 KTS

Figure 3. Expanded Search Area

the eastern end of the search area. Figure 4, Search Area Display Contacts Identified During STS 51-L Search Operations, shows the location of all sonar contacts. Many of the contact locations defined debris fields which contained more that one and, in a few cases, up to 500 individual pieces of debris. Each debris field was assigned one contact number and all pieces in a field were listed and tracked under that contact number for management purposes.

D. *Remarks on Search Operations*

1. *Accuracy of Sonar Located Contacts.*

The actual location of the contacts identified during side scanning search operations proved accurate to within ± 35 meters in shallow water depths and ± 100 meters in deeper water depths. These location inaccuracies can be attributed to a combination of errors induced by:

(a) Navigational systems.

(b) Vortex shedding due to cross currents in the water column (stronger in deeper depths) resulting in transverse instability of the towed sonar "fish".

(c) Small variations in towing ship course, speed and ship motion (pitch and roll) due to winds and sea state, resulting in tow cable variations and additional sonar "fish" relative position errors.

These contact location inaccuracies were acceptable, as they were within the capabilities of ROV and manned submersible sonars and divers to relocate.

2. *Side Scanning Sonar Remarks*

(a) The tow speed of the side scanning sonar is important. If the speed is too slow, it will "slur" the trace and, if the speed is too fast, it may not adequately map ("paint") the contacts. Tow speeds of 2-4 knots are normal for side scanning sonar operations and this speed range proved acceptable for this operation as well. This speed is calculated with respect to the bottom (i.e., speed over ground or SOG) and not the ship's speed through the water. Therefore, a ship towing at 4 knots into a 2-knot current would only make 2 knots SOG.

(b) The stability of the towed sonar cylindrical tube, or "fish", is dependent upon its relative speed through the water, motion stability of the tow vessel, and cross currents. A higher relative speed and, therefore, more stability, is obtained by towing the "fish" into the current. Given the high Gulf Stream currents in this search area, it was necessary to tow into the current (i.e., ship heading south) most of the time. Motion stability (course, speed, pitch, and roll) of the tow vessel also affects the stability of the tow "fish." The more constant the motion stability of the vessel, the more stable the "fish" in both depth and transverse accuracy.

(c) Since a 165-meter (122 percent) overlap of bottom area coverage was used and the combined maximum sonar search transverse errors (detailed previously in paragraph III.D.1) were estimated to be a maximum of 100 meters, there is a high confidence that the search area bottom was fully covered. Detailed evaluation and comparison of adjacent search line bottom area coverage sonar traces also verified full coverage was obtained (i.e., the same contacts appeared in the overlap area of adjacent traces).

IV. *CONTACT CLASSIFICATION RESULTS*

A. *Introduction*

Contact classification operations involved the collection of supporting evidence and documentation to determine the identity of contacts located during search operations. Supporting evidence and documentation for contact classification included: still photography, video tapes, manned submersible operator descriptions, diver descriptions, and the recovery of small pieces of debris if they appeared to be STS 51-L related and did not require special handling. NASA and SUPSALV personnel reviewed and evaluated the photographs, video tapes, diver reports, and associated recovered small items of debris to positively classify contacts. Three major classification categories were used: STS 51-L, Non-STS 51-L, and Unconfirmed. Contacts classified as STS 51-L debris were further assigned to one of the following major system categories: Orbiter (including Payload), Left SRB, Right SRB, External Tank, or to Shuttle if it could not be positively linked to one of the other categories.

B. *NASA Priority Assignments for Recovery*

Contacts classified as STS 51-L debris were prioritized by NASA to determine the order of recovery. Priorities were established based on (1) importance of object recovery relative to determining cause of mishap, and (2) humanitarian considerations. During the course of the salvage effort, established priorities were continually reviewed and revised as additional data and information concerning the sonar contacts was compiled. Daily meetings were convened between NASA, SUPSALV, DDMS, and ESMC to review STS 51-L Salvage Operations progress, redefine priorities, determine the specific employment of assets, and resolve technical problems associated with the recovery process.

C. *Summary of Classification Efforts*

Of the 691 contacts located during search operations through May 1, 1986, 490 contacts have been classified, 82 of which were classified as STS 51-L debris. Table 2, Summary of Contacts Classified STS 51-L Debris, provides a summary of pertinent classification information. Figure 5, Search Area Display of Contacts Classified STS 51-L Debris, shows the general location of contacts from Table 2. Note that in may cases (reference Table 2), a contact defines a field (area) of contacts versus just a single contact. This tracking method was used in order to reduce the monitoring of contacts to a manageable level. All contacts within a given field were normally investigated during classification operations.

D. *Remarks on Classification Operations*

1. *Bottom Topography*

Bottom topography within the search areas was a major factor with respect to the classification of contacts. Much of the actual STS 51-L debris consisted of small pieces (e.g., 1 ft. × 1 ft. and smaller); therefore, small local natural topographic features were the primary cause for the classification of Non-STS 51-L contacts. These contacts included: conch and clam shells, fish bed holes and mounds, coral heads, and small ridges. Shells were a problem in water depths of 60 to 200 feet. Fish beds were identified in water depths of 400 to 800 feet. Coral heads were located over small areas in water depths of 60 to 200 feet. Two ridge lines were identified, both of which run in a nearly north-south direction. One ridge line is located four miles from the eastern edge of search area A in approximately 1,000 feet of water. The other ridge line is located in the east central region of search areas A and B in 400 to 600 feet of water.

2. *Discarded Equipment*

The search area lies directly over a major merchant shipping lane and vessels navigating the area have occasionally dumped items of equipment into the ocean. Many contacts were, therefore, randomly scattered items of equipment such as 55-gallon drums, coils of wire, refrigerators, etc.

3. *Aerospace Debris*

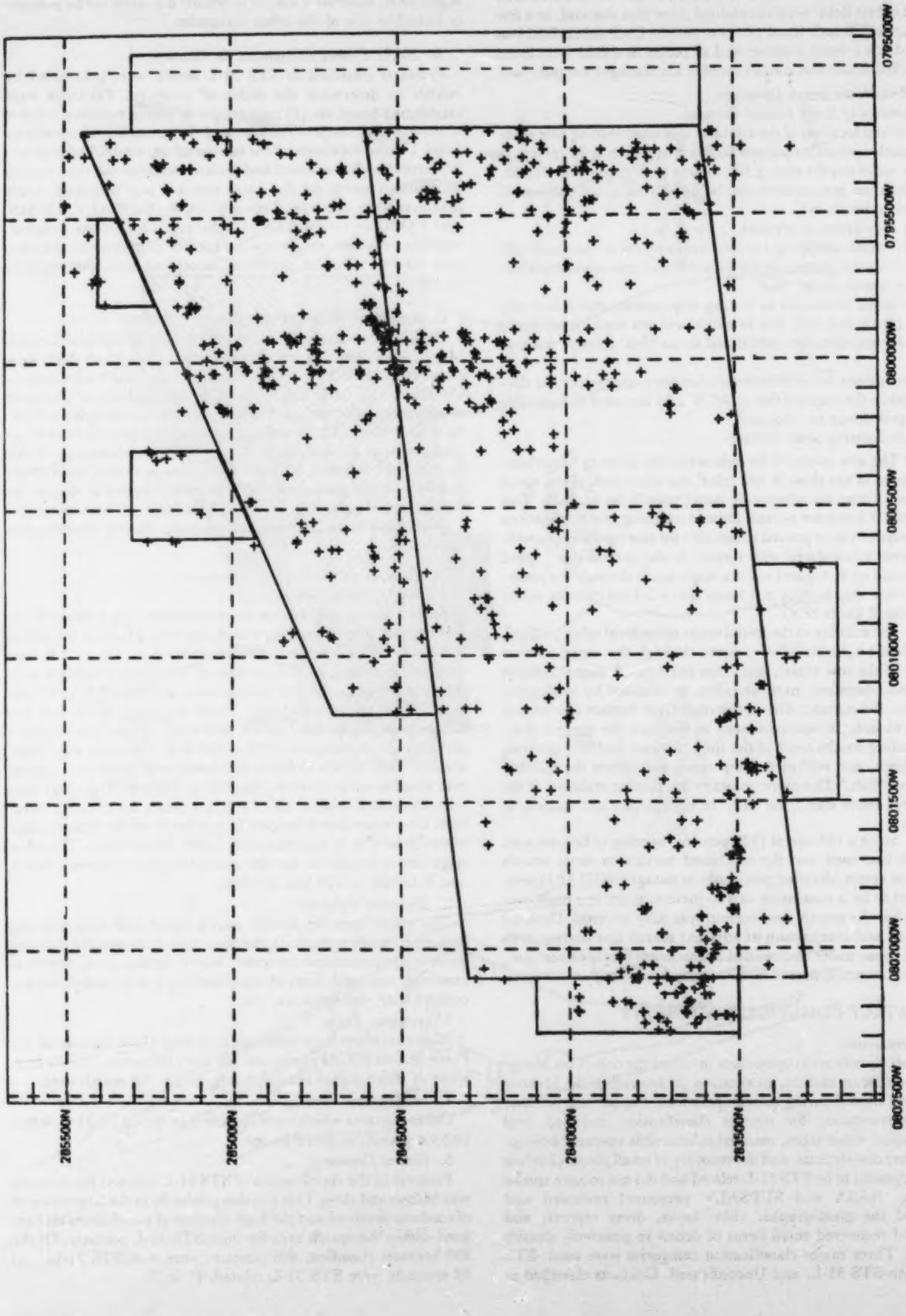
Many launches have been initiated from Cape Canaveral Air Force Station (CCAFS) over the last forty (40) years. Debris from some of these flights lies randomly within the search area.

4. *Miscellaneous Contacts*

Other contacts which were classified as Non-STS 51-L debris include planes, shipwrecks, etc.

5. *General Comments*

Progress in the classification of STS 51-L contacts for recovery was tedious and slow. This was due primarily to the large number of contacts involved and the high number of possibilities that existed within the search area for Non-STS 51-L contacts. Of the 490 contacts classified, 408 contacts were Non-STS 51-L, and 82 contacts were STS 51-L related. (1 in 5).



285500N
285000N
284500N
284000N
283500N
0795000W
0795500W
0800000W
0800500W
0801000W
0801500W
0802000W
0802500W

Figure 4. Search Area Display of Contacts Identified During STS 51-L Search Operations

Table 2. Summary of Contacts Classified STS 51-L Debris
(Sheet 1 of 2)

CONTACT SUMMARY FOR SENSOR GROUP 11 C CONTACTS AS OF 01 May 86

ID	DATE FOUND	LAT DDMMSSN	LONG DDDMMSSW	LEN (m)	WID (m)	ANG deg	CODE	REMARKS	EST# OBJ	FSW
0003	7 Feb86	283513N	0801649W	28	28	0	TSR	ExtTankPiece(LS/SL/SB)	10	100
0004	7 Feb86	283454N	0801644W	26	26	0	TMR	ExtTankPiece(LS/DD/SB)	1	100
0008	10 Feb86	283543N	0802010W	27	27	0	OSR	HydraulicLines(FS/DD*)	1	100
0010	10 Feb86	283829N	0802013W	28	28	0	OSR	OrbEngParts (FS/DD/PR)	10	82
0011	11 Feb86	283843N	0800630W	26	26	0	LLR	SRBFwdAftSeg(LS/DD/GE)	1	215
0021	4 Feb86	284900N	0795227W	406	26	0	RLR	SRBAftSegSkt(LS/SL/GE)	500	1200
0023	13 Feb86	283829N	0802020W	27	27	0	OSR	OrbEngParts (FS/VN*)	10	100
0024	16 Feb86	284310N	0795422W	706	156	340	LM	SRB Aft Aft Seg(LS/SL)	15	1050
0026	12 Feb86	284301N	0800538W	15	10	0	LLR	SRBFwdAftCtr(LS/SL/GE)	2	240
0029	8 Feb86	283503N	0801618W	32	32	0	TLR	ExtTankPiece (LS/SL*)	1	100
0030	8 Feb86	283456N	0801638W	13	13	0	OMR	3'CablTrayExit(LS/SL*)	1	100
0041	21 Feb86	284215N	0800117W	12	12	0	LLF	SRMw/ignitr12'D(LS/SL)	1	400
0055	15 Feb86	283506N	0801839W	12	12	0	TM	4'x6'MetlObj (FS/DD)	1	100
0056	16 Feb86	283530N	0801813W	12	12	0	OL	MidBodFlrPce (FS/DD)	1	100
0060	26 Feb86	283357N	0801409W	12	12	0	OM	SevHrdSnglCnts (FS/DD)	2	120
0066	8 Feb86	283828N	0802047W	12	12	0	OLR	MainOrbEngNozz(FS/PR*)	9	90
0068	8 Feb86	283605N	0802101W	12	12	0	OLR	AftFuselage (FS/VN*)	2	90
0071	9 Feb86	283609N	0802037W	12	12	0	OSR	Orbiter Parts (FS/IN*)	6	90
0072	9 Feb86	283815N	0802042W	12	12	0	OMR	Orbiter Parts (FS/IN*)	5	82
0077	10 Feb86	283608N	0802006W	12	12	0	OMR	OrbitrSidewall(FS/GP*)	1	74
0078	10 Feb86	283605N	0802004W	12	12	0	OMR	ConeShp+OthJnk(FS/GP*)	1	74
0131	1 Mar86	284223N	0800024W	12	12	0	RLR	SRBSknW/Burn(LS/NR/GE)	1	560
0183	11 Feb86	283557N	0801942W	12	12	0	TMR	6'x15'CurvdPce(FS/GP*)	1	100
0185	12 Feb86	283714N	0801928W	12	12	0	OL	PosRDR5'x8'&Deb(FS/DD)	6	75
0191	8 Feb86	283507N	0801649W	12	12	0	OL	SectTiles (FS/DD)	1	100
0192	8 Feb86	283826N	0801703W	12	12	0	OLR	OrbHydrzTank(FS/DD/GW)	2	102
0195	28 Feb86	284617N	0800219W	12	12	0	RLR	SRBFwdAftCtr(GW/SL/GE)	1	426
0196	28 Feb86	284150N	0800227W	12	12	0	BMR	SRBETAtW/Clv(GW/NR/GE)	1	360
0214	3 Mar86	284210N	0800855W	12	12	0	BLR	LgCurvedPce (P3/DD/KW)	1	192
0292	26 Feb86	284519N	0795905W	12	12	0	RMR	SRBFwdAftSeg(LS/SL/GE)	2	590
0301	28 Feb86	284421N	0800012W	15	15	0	RLR	SRBAftFwdSeg(LS/SL/GE)	1	590
0312	24 Feb86	284521N	0795858W	12	12	0	BLR	2 6"WtSqs&Blts+(LS/SL)	2	558
0325	5 Mar86	284420N	0800923W	12	12	0	RMR	SRBAftAftCtr(P3/DD/SB)	1	168
0345	5 Mar86	284342N	0795312W	12	12	0	BM	SRBMtrSkn4x3' (LS/NR)	1	1050
0349	6 Mar86	284418N	0795421W	12	12	0	BM	SRB Nozzle (LS/SL)	1	93
0351	6 Mar86	284350N	0795424W	75	75	0	LM	SRBDebFldPos#24(LS/NR)	15	935
0417	8 Mar86	284406N	0795425W	10	10	0	LM	SRBMtrSkW/YelIn(LS/NR)	1	920
0433	9 Mar86	284343N	0795948W	10	10	0	RMR	SRBAftCtrSeg(LS/SL/GE)	1	600
0443	8 Mar86	284320N	0795429W	10	10	0	LL	LSRB DebrisArea(LS/NR)	1	1020
0468	12 Mar86	284240N	0795944W	10	10	0	BLR	SRBPceW/8'Mk(LS/NR/GE)	1	500
0487	12 Mar86	283946N	0800452W	10	10	0	BLR	SRBSknW/Clv (GP/NR/SL)	1	245
0497	12 Mar86	284510N	0795854W	10	10	0	BLF	StbRgFrstrm&Shr(LS/SL)	2	805
0502	12 Mar86	284526N	0795934W	10	10	0	RLR	SRBAftFwdCtr(LS/SL/GE)	2	750
0503	12 Mar86	284419N	0795931W	10	10	0	BMF	SRBClvs&FwdSkrt(LS/EL)	1	620
0504	12 Mar86	284417N	0795930W	10	10	0	BLF	MtrCsngW/Ignitr(LS/EL)	1	620
0510	12 Mar86	284452N	0795734W	10	10	0	BLR	SRBETAttRng?(GP/NR/SL)	1	820
0517	16 Mar86	284125N	0800301W	10	10	0	BLF	SRBNozzle (LS/EL)	1	460
0520	16 Mar86	283652N	0802132W	10	10	0	OLR	LftAftFuselage(FS/GP*)	1	85
0524	16 Mar86	284133N	0800220W	10	10	0	BLR	SRBSkn12x18'(LS/NR/GE)	1	370
0530	16 Mar86	283711N	0802132W	10	10	0	OLR	VertStabilizer(FS/PR*)	1	65
0538	16 Mar86	284503N	0795817W	10	10	0	RLR	FwdSkrt&Chut(GW/SL/GE)	2	910
0555	16 Mar86	283757N	0802102W	10	10	0	OLR	Orbiter Piece (FS/PR*)	1	75
0558	16 Mar86	283625N	0802146W	10	10	0	OLR	OrbEngNozzle (FS/VN*)	2	80
0560	16 Mar86	283629N	0802150W	40	10	0	TL	LgPceExtrnlTnk(FS/IN*)	3	75
0563	17 Mar86	283722N	0802221W	10	10	0	OL	VertAcceleratr(FS/OP*)	1	75
0564	18 Mar86	283708N	0802230W	10	10	0	OLR	AftCrgoBlkHd(FS/P3/OP)	1	65
0566	17 Mar86	283749N	0802209W	10	10	0	OLR	OrbRtWing (FS/VN*)	20	85

Table 2. Summary of Contacts Classified STS 51-L Debris
(Sheet 2 of 2)

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0567 18 Mar86 283702N 0802248W  10  10  0 OLR Electronix&Wir(FS/KW*)   2    82
0568 18 Mar86 283723N 0802245W  10  10  0 OLR LftFuseSidWall(FS/VN*)   1    65
0571 18 Mar86 283746N 0802232W  10  10  0 OL  OrbRtSidePces (FS/OP*)   2    70
0572 18 Mar86 283757N 0802053W  10  10  0 OMR Orbiter Piece (P3/PR*)   1    75
0579 20 Mar86 284912N 0795826W  10  10  0 RMR SRBFwdAftSeg(GP/NR/GE)   2   790
0595 17 Mar86 283541N 0802216W  10  10  0 OLR OrbLftWngPces (FS/IN*)   1   100
0605 24 Mar86 284231N 0800302W  10  10  0 BMR SRBSkClvInhb(LS/NR/GE)   1   315
0615 27 Mar86 284620N 0800345W  10  10  0 RMR SRBFwdFwdCtr(LS/SL/GE)   1   328
0631  2 Apr86 285237N 0795538W  10  10  0 BMR SRBPceClv&Tg(LS/NR/GE)   1  1033
0635  4 Apr86 284550N 0800147W  10  10  0 BMR SRBFwdMtrCsg(NR/NR/GE)   1   450
0699 13 Apr86 284609N 0800024W  10  10  0 BMR SRBCtrFwdSeg(FS/EL/GE)   1   720
0711 11 Mar86 284419N 0795919W  10  10  0 BMR SRB Piece     (LS/GE*)   1   656
0712 11 Mar86 284358N 0795917W  10  10  0 RSR SRBAftSegAttch(LS/GE*)   1   656
5038  7 Apr86 284551N 0795758W  10  10  0 BLR SRBSkinW/Clv(NR/SL/GE)   1  1000
5039  7 Apr86 284548N 0795800W  10  10  0 BLR SRBSkinW/Tng(NR/SL/GE)   1  1000
5124  5 Apr86 284022N 0800229W  10  10  0 LMR SRB ET Strut(NR/SL/GE)   1  1000
5125  7 Apr86 284535N 0795719W  10  10  0 BMR PossSRBCase   (NR/GE*)   1  1000
5126  7 Apr86 284548N 0795757W  10  10  0 BMR SRBSkn-3Pces(NR/SL/GE)   3  1000
5127  7 Apr86 284600N 0795758W  10  10  0 BLR SRBPce3x5'    (NR/GE*)   1  1000
5128  7 Apr86 284552N 0795801W  10  10  0 BMR SRBSkn6x4.5'(NR/SL/GE)   1  1000
5433  1 Apr86 284341N 0795944W  10  10  0 BMR SRBMtrSkn6"Inh(NR/GE*)   1   600
5632  9 Apr86 284747N 0795538W  10  10  0 BM  SRBMtrSkn2.5'Sq(LS/NR)   1  1000

Number of entries=  79
                        Key to CODE
S = Shuttle System        S = Small (<3')          R = Recovered
O = Orbiter & Cargo       M = Medium (3'-10')      F = Forget It
L = Left SRB              L = Large (>10')
R = Right SRB
B = Unknown SRB
T = External Tank
M = Miscellaneous Space Debris
A = Aircraft
W = Shipwrecks
G = Geological Feature
J = Other Junk
N = Nothing Found
U = Unconfirmed
XXX = Same as another contact

OVERALL STATISTICS
 Total Number of Contacts            691
 Total Investigated                  490
 Total Shuttle Contacts              82
 Total Recovered Shuttle Contacts    62
 Total Booster Contacts              46
 Total Recovered Booster Contacts    34
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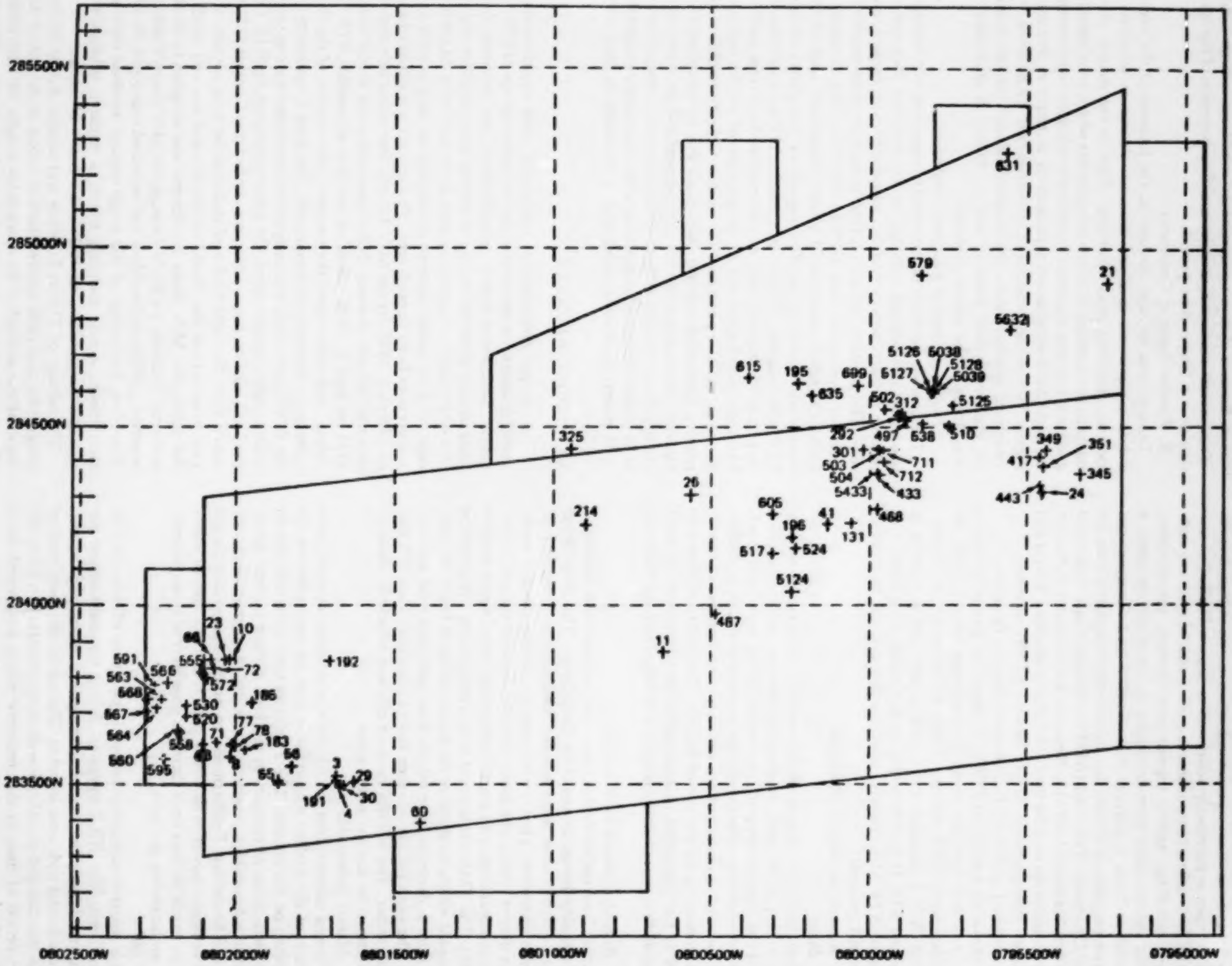
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635
699
5126
5038
5127
5128
5039
502
312
5125
292
497
538
510
325
349
351
417
345
301
503
504
711
712
5433
433
443
24
26
605
41
131
468
214
196
524
517
5124
467
11
192
23
10
66
591
566
555
72
563
572
568
186
530
567
520
77
78
564
71
183
558
58
560
595
65
3
29
191
30
4
80

Figure 5. Search Area Display of Contacts Classified STS 51-L Debris

V. *RECOVERY RESULTS*

A. *Introduction*

Contacts classified as STS 51-L debris was prioritized by NASA for order of recovery. Procedures for establishing priorities for recovery and coordinating asset utilization were conducted in the same manner as previously addressed in Section IV.B. For major STS 51-L debris components requiring special recovery techniques, handling, and/or topside post-recovery preparations, specific salvage plans were developed. A list of salvage plans is provided as Table 3, Salvage Plans for STS 51-L Components.

Upon completion of recovery, debris was transported from the Naval Ordinance Test Unit (NOTU) through Cape Canaveral Air Force Station (CCAFS) to Kennedy Space Center (KSC) for analysis and evaluation by the NASA Reconstruction Teams and National Transportation Safety Board (NTSB) members.

B. *Summary of STS 51-L Underwater Recovery Operations*

A total of 62 individual STS 51-L objects or groups of objects were recovered from the ocean floor through May 1, 1986, 34 of which were SRB debris. Table 4, Summary of Underwater STS 51-L Contacts Recovered, is provided as a listing of recovered STS 51-L debris. Figure 6, Search Area Display of Salvaged STS 51-L Debris, provides the general location of recovered contacts.

C. *Remarks on Recovery Operations*

1. *Divers*

Divers were used extensively for recovery operations in shallow water area, (70-300 feet). Surface-supplied air, surface-supplied mixed gas (helium/oxygen), and scuba diving were conducted. Divers proved to be effective for the recovery of debris in shallow areas, where low ocean bottom visibility often imposes an operational limitation on the use of ROV's. The ability of divers to "work by feel" also proved advantageous for the recovery of items in the shallow areas where visibility was frequently less than one foot.

2. *Remotely Operated Vehicles (ROV's)*

Strong currents throughout the water column and occasional poor visibility limited the use of the Deep Drone. The Deep Drone was an effective asset when current conditions and visibility allowed employment. The Gemini proved to be very effective working in deeper depths and higer currents. Gemini utilized a two-cable configuration with a heavy depressor/tether winch module (TMS). The TMS was lowered to operating depth and provided additional weight to stabilize the main umbilical below the support ship. It decoupled the vehicle from umbilical drag and motion. The work vehicle was then free to maneuver via a 500-foot vehicle tether. The SCORPI was an efficient vehicle for classifying contacts in shallow water areas.

3. *Manned Submersibles*

Manned submersibles, which are not tethered, operate independent of the surface support ship and are very effective for operating on the bottom. These vehicles were most effective in the classification of contacts in the high surface current areas. Manned submersibles, however, are limited to operational periods of 6 to 8 hours/day. Furthermore, manned submersibles do not have sufficient power to lift heavy objects nor can they be easily used to attach lift lines since there is a possibility of entanglement, thus endangering the crew.

4. *NR-1*

This research submarine proved to be a very effective and efficient asset. The NR-1 operated during the most severe environmental conditions, stayed submerged for extended durations, and conducted wide area searches. The use of this asset resulted in the location and classification of many contacts in a relatively short period of time so that recovery efforts progressed more effectively.

5. *Effects of Environment*

Environmental factors were the major obstacles during this salvage operation. Weather systems resulting in high sea states and water turbidity contributed to lost time due to inability to launch and retrieve assets and loss of underwater visibility. The effects of currents at all locations in the water column severely hindered the operations of the divers, ROV's, manned submersibles, and side scanning sonar. Silt buildup, as much as two feet in some areas, severely reduced the ability to locate and recover debris. Because of these environmental conditions, a large number of assets were employed, thereby avoiding extension of the operation over a longer time period.

6. *Random Scatter of Components*

During most salvage operations, the location of the various debris components involved becomes clearer as contacts are located, classified, and recovered. Due to the nature of this mishap, the location of debris components which were classified and recovered was random. Structurally adjacent components of the right SRB were found separated by as much as five miles. Figure 7 shows the locations of recovered right SRB debris. The associated numbers show the assigned salvage contact number for each recovered piece of debris. Figure 8 illustrates the magnitude of the scatter problem.

7. *Position Accuracy of Recovered Components*

The position accuracy of recovered components was dependent upon the navigational accuracy of the recovery ship and the relative position accuracy of the component with respect to the ship. The primary navigation system used by ships conducting recovery operations was GPS/LORAN-C. The accuracy of GPS/LORAN-C was 10 to 25 meters, dependent upon whether fixes were based on satellite signals or compared/corrected LORAN-C signals. The relative position of the component with respect to the recovery ship was determined by several methods. Methods included the use of: pingers placed on the contact to determine relative position, ROV or manned submersible-to-ship relative positioning systems, and direct ship-to-component wire cable(s). Dependent upon the method used and the water depth, the ship-to-component relative position accuracy ranged from 10 to 25 meters. Recorded component position accuracy ranged from ± 35 meters in shallow water and ± 50 meters in deep water.

VI. CLOSING REMARKS

The proper employment, utilization, and coordination of available assets was essential to the successful salvage of STS 51-L debris. Concurrent search, identification, and recovery operations usually involved the use of several assets to affect recovery of a single object. A good example is Contact #131 which is the right SRB aft center segment containing the tang portion of the suspect joint burn through area. This contact was initially located on March 1, 1986, by the M/V Liberty Star using side scanning sonar in 560 feet of water. NR-1 operated at the site of Contact #131 on Apil 5, 1986, classified the item as possible STS 51-L debris, and video taped the contact. After review of the NR-1 video tape, the manned submersible, Sea Link I, operating from the R/V Edwin Link, was assigned to investigate the contact and obtain higher-quality video. On a dive conducted April 12, 1986, the Sea Link I on-board observers verified that Contact #131 was debris from the right SRB and included the tang portion of the joint area in question. Based on the physical size and weight of the debris, the M/V Stena Workhorse was assigned to conduct recovery. Utilizing the ROV Gemini, the M/V Stena Workhorse attached a lift line to the debris and recovered it on April 13, 1986. Therefore, the salvage of this single contact involved three surface vessels, a side scanning sonar, a research submarine, a manned submersible, an ROV, and heavy-lift crane.

The salvage of STS 51-L debris was unique due to the large geographic size (480 square nautical miles) of the search area, the small size of much of the debris being sought, the large number of contacts requiring investigation, and the random dispersion of STS 51-L on the ocean bottom. Environmental conditions within the search area were severe and varied, and often reduced, or even totally curtailed, the operational effectiveness of the STS 51-L salvage operations. These environmental conditions, coupled with the enormity of scope of this operation, necessitated the simultaneous employment of many different types and numbers of assets. Never before has a massive search and salvage operation of this scope and detail been undertaken. The establishment of a sound organization, strong cooperation within this organization, efffective coordination of information and assets, and dedicated personal efforts by both salvage and reconstruction team members, were essential to the success of the STS 51-L Salvage Operation.

Table 3. Salvage Plans for STS 51-L Components (Sheet 1 of 3)

PLAN #	CONTACT#	DESCRIPTION	DATE PLAN REPORT
Basic	N/A	Plan for SRB Retrieval Operations	26 FEB 86
Basic	N/A	Plan for SRB Salvage Off-Load and Transport to Storage Facility	6 MAR 86
SRB-1	C0011	Plan for Left Hand SRB Aft Segment/ET Attach Ring Segment Retrieval Operations	26 FEB 86
SRB-2	C0026 (TAR #26-1)	Plan for Left Hand SRB Aft Center Segment/Fwd Case Segment Retrieval Operations	3 MAR 86
SRB-3	C0026 (TAR #26-2)	Plan for Left Hand SRB Aft Center Segment/Fwd Case Segment Retrieval Operations	3 MAR 86
Adden. No. I	C0001	Addendum No. I (R.H. SRB Aft Seg/ Dome Stiffener Seg) to Requirements for 51-L SRB Retrieval Operations	6 MAR 86
Adden. No. II	C0021	Addendum No. II (SRB Case Tang Segment) to Requirements for 51-L SRB Retrieval Operations	7 MAR 86
Adden. No. III	C0021	Addendum No. III (SRB Aft Seg/ Stiffener/Stiffener with Tunnel Segment) to Requirements for 51-L SRB Retrieval Operations	7 MAR 86
Adden. No. IV	C0021	Addendum No. IV (SRB Aft Seg/ Stiffener Segment with Clevis) to Requirements for 51-L SRB Retrieval Operations	7 MAR 86
Adden. No. V	C0024	Addendum No. V (L.H. SRB Aft Seg/ Dome/Kick Ring) to Requirements for 51-L SRB Retrieval Operations	12 MAR 86
Adden. No. VI	C0041	Addendum No. VI (SRB Fwd Seg Dome/Igniter) to Requirements for 51-L SRB Retrieval Operations	13 MAR 86
Adden. No. VII	C0301	Addendum No. VII (SRB Case Cylinder Seg) to Requirements for 51-L SRB Retrieval Operations	13 MAR 86

Table 3. Salvage Plans for STS 51-L Components (Sheet 2 of 3)

PLAN #	CONTACT#	DESCRIPTION	DATE PLAN REPORT
Adden. No. VIII	C0292	Addendum No. VIII (SRB Aft Seg/ET Attach Seg) to Requirements for 51-L SRB Retrieval Operations	14 MAR 86
Adden. No. IX	C0195	Addendum No. IX (SRB Case Cylinder Seg) to Requirements for 51-L SRB Retrieval Operations	14 MAR 86
Adden. No. X	C0021	Addendum No. X (SRB Aft Seg-Fwd Stiffener) to Requirements for 51-L SRB Retrieval Operations	22 MAR 86
Adden. No. XI	C0021	Addendum No. XI (SRB Aft Seg-Stiffener) to Requirements for 51-L SRB Retrieval Operations	22 MAR 86
Adden. No. XII	C0021	Addendum No. XII (SRB Aft Seg-Ring) to Requirements for 51-L SRB Retrieval Operations	22 MAR 86
Adden. No. XIII	C0021	Addendum No. XIII (SRB Aft Seg-Fragment) to Requirements for 51-L SRB Retrieval Operations	22 MAR 86
Adden. No. XIV	C0502	Addendum No. XIV (SRB Cyl Seg-Fld Joint Tang) to Requirements for 51-L SRB Retrieval Operations	25 MAR 86
Adden. No. XV	C0325	Addendum No. XV (SRB Case Cyl-Clevis Joint) to Requirements for 51-L SRB Retrieval Operations	25 MAR 86
Adden. No. XVI	C0021 (TAR #29-1)	Addendum No. XVI (SRB Case Cyl-Clevis and Tang Joint) to Requirements for 51-L SRB Retrieval Operations	29 MAR 86
Adden. No. XVII	C0214 (TAR #214)	Addendum No. XVII (SRB Case Segment) to Requirements for 51-L SRB Retrieval Operations	3 APR 86
Adden. No.XVIII	C0615 (TAR#615-1)	Addendum No. XVIII (SRB Case Cyl-Tang) to Requirements for 51-L SRB Retrieval Operations	4 APR 86
Adden. No. XIX	C0615 (TAR#615-2)	Addendum No. XIX (SRB Case Cyl-Clevis) to Requirements for 51-L SRB Retrieval Operations	4 APR 86

Table 3. Salvage Plans for STS 51-L Components (Sheet 3 of 3)

PLAN #	CONTACT#	DESCRIPTION	DATE PLAN REPORT
Adden. No. XX	C0345 C0417 C0487 C0632	Addendum No. XX (SRB Hardware) to Requirements for 51-L SRB Retrieval Operations	17 APR 86
Adden. No. XXI	C0579	Addendum No. XXI (SRB Aft Seg-ET Attach) Requirements for 51-L SRB Retrieval Operations	4 APR 86
Adden. No. XXII	Various (See Note 1)	Addendum No. XXII (SRB Hardware) to Requirements for 51-L SRB Retrieval Operations	11 APR 86

NOTE 1: C0021, C0024, C0041, C0131, C0196, C0214, C0325, C0433, C0468, C0503, C0504, C0510, C0524, C0605, C0615, C0631, C0635, C5038, C5039, C5124, C5125, C5126, C5128

Table 4. Summary of Underwater STS 51-L Contacts Recovered

System	Contact Number	Remarks
Right SRB	0021	Aft Segment Skirt
	0131	Aft Center Segment w/Burn Area
	0195	Forward Aft Center Segment
	0292	Forward Aft Segment
	0301	Aft Forward Segment
	0325	Aft Center Segment
	0433	Aft Center Segment
	0502	Forward Center Segment
	0538	Forward Skirt and Parachute
	0579	Aft Segment
	0615	Forward Center Segment
	0712	Aft Segment w/Burn Area
Orbiter	0008	Hydraulic Lines
	0010	Engine Parts
	0023	Engine Parts
	0030	3' Cable Tray Exit
	0066	Main Orbiter Engine Nozzle
	0068	Aft Fuselage
	0071	Miscellaneous Small Hardware
	0072	Miscellaneous Medium Hardware
	0077	Medium Sidewall Piece
	0078	Medium Cone Shape
	0192	Large Hydrazine Tank
	0520	Left Aft Fuselage
	0530	Vertical Stabilizer
	0555	External Large Piece
	0558	Engine Nozzle
	0564	Aft Cargo Hold
	0566	Right Wing
	0567	Electronics and Wiring
	0568	Left Fuselage Sidewall
	0572	External Medium Piece
	0595	Large Left Wing Piece
	****	Crew Compartment
	****	Orbiter Cargo
	****	Orbiter Cargo
Left SRB	0011	Forward Aft Segment
	0026	Forward Aft Center Segment
	5124	SRB External Tank Strut
External Tank	0003	External Small Pieces
	0004	External Medium Piece
	0029	External Large Piece

Table 4. Summary of Underwater STS 51-L Contacts Recovered

System	Contact Number	Remarks
Booster, Unknown Side	0196	External Tank Attachment w/Clevis
	0214	Large Curved External Piece
	0312	Large External Piece
	0468	Large External Piece
	0487	Large External Piece w/Clevis
	0510	Large External Piece
	0524	Large External Piece
	0605	Medium External Piece
	0631	Medium External Piece w/Clevis and Tang
	0635	Forward Motor Casing
	0699	Forward Segment
	0711	Medium External Piece
	5038	Large External Piece w/Clevis
	0539	Large External Piece w/Tang
	5125	Medium External Piece
	5126	Medium External Pieces (3)
	5127	Large External/Internal Piece
	5128	Medium External Piece
	5433	Medium Motor Skin Piece

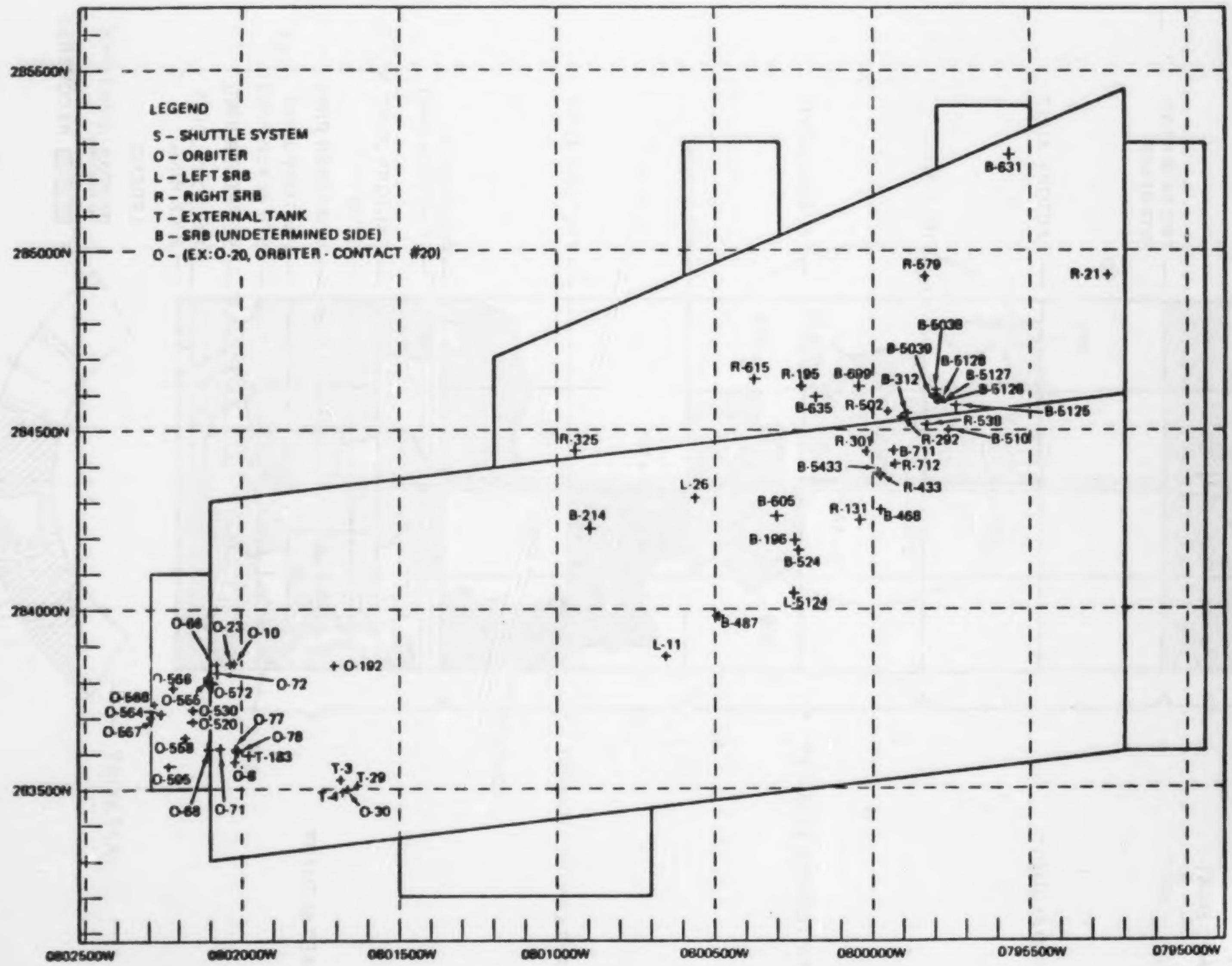
285500N
285000N
284500N
284000N
283500N
0802500W
0802000W
0801500W
0801000W
0800500W
0800000W
0795500W
0795000W
LEGEND
S – SHUTTLE SYSTEM
O – ORBITER
L – LEFT SRB
R – RIGHT SRB
T – EXTERNAL TANK
B – SRB (UNDETERMINED SIDE)
O – (EX: O-20, ORBITER - CONTACT #20)
B-631
R-679
R-21
B-5038
B-5030
B-5128
B-5127
B-5126
B-5125
B-312
R-502
R-530
R-292
B-510
R-615
R-195
B-699
B-635
R-301
B-711
R-712
B-5433
R-433
R-325
L-26
B-605
R-131
B-468
B-214
B-196
B-524
L-5124
B-487
L-11
O-66
O-23
O-10
O-72
O-192
O-566
O-572
O-565
O-588
O-564
O-530
O-520
O-567
O-77
O-78
T-183
O-569
O-8
O-505
O-68
O-71
T-3
T-29
T-4
O-30

Figure 6. Search Area Display of Salvaged STS 51-L Debris

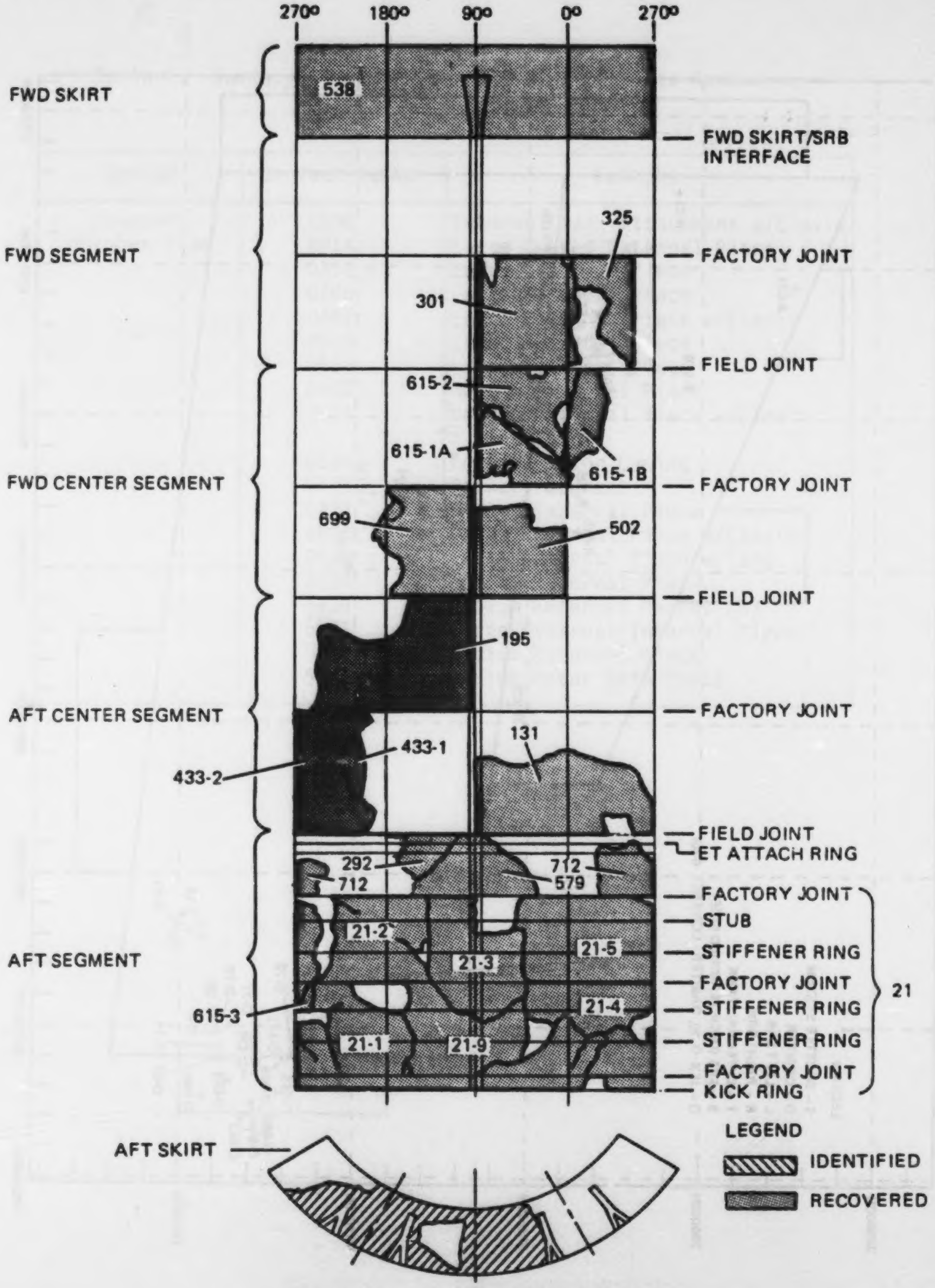
270°
180°
90°
0°
270°
FWD SKIRT
538
FWD SKIRT/SRB INTERFACE
FWD SEGMENT
325
FACTORY JOINT
301
FIELD JOINT
615-2
615-1A
615-1B
FWD CENTER SEGMENT
FACTORY JOINT
699
502
FIELD JOINT
195
AFT CENTER SEGMENT
FACTORY JOINT
131
433-1
433-2
FIELD JOINT
ET ATTACH RING
292
712
712
579
FACTORY JOINT
STUB
21-2
21-3
21-5
STIFFENER RING
AFT SEGMENT
FACTORY JOINT
21
615-3
21-4
STIFFENER RING
21-1
21-9
STIFFENER RING
FACTORY JOINT
KICK RING
AFT SKIRT
LEGEND
▨ IDENTIFIED
▩ RECOVERED

Figure 7. RH SRB Located Debris

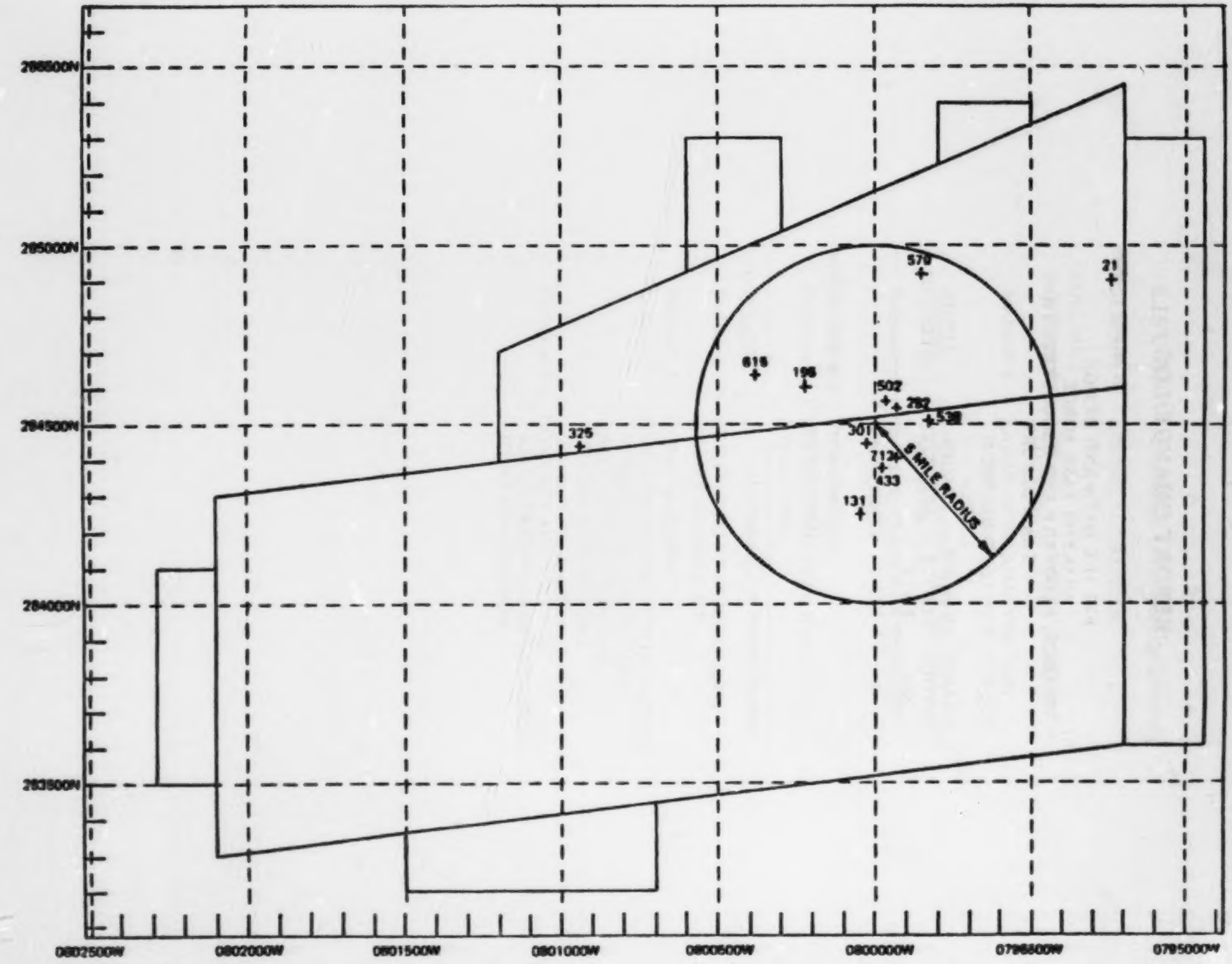
285500N
285000N
284500N
284000N
283500N
0802500W
0802000W
0801500W
0801000W
0800500W
0800000W
0795500W
0795000W
5 MILE RADIUS
570
21
618
198
502
282
538
301
712
433
131
325

Figure 8. RH SPR Locations

REPORT CHANGE LOG

as of *May 12,1986*

STS 51-L DATA AND DESIGN
ANALYSIS TASK FORCE
SEARCH, RECOVERY AND RECONSTRUCTION
TEAM REPORT

VOLUME 3

CHANGE NOTICE NO.	CHANGE NOTICE DATE	PAGES AFFECTED	ITEMS AFFECTED
1	5/12/86	Create Volume 3	
		Enclosure 5 (From Volume 2)	Complete Update

Colonel Edward A. O'Connor, Jr.

Date

LIST OF VOLUMES (separately bound)

VOLUME 1	REPORT SUMMARIES
VOLUME 2	
Enclosure 1	MISSION 51-L SHUTTLE MISHAP – SURFACE SEARCH
Enclosure 2	RADAR DATA ANALYSIS AND IMPACT ESTIMATION FOR STS 51-L DEBRIS
Enclosure 3	STS 51-L RIGHT SRB REPORT NO. 82-SR-86-07
Enclosure 4	SEARCH, CLASSIFICATION AND RECOVERY
VOLUME 3	THIS VOLUME
Enclosure 5	SRB INCREMENTAL RECOVERY PLANNING
VOLUME 4	
Enclosure 6	RECOVERED ET DEBRIS HARD WARE ASSESSMENT
Enclosure 7	OCEANOGRAPHY
Enclosure 8	SPACE TRANSPORTATION SYSTEM, MISSION 51-L STRUCTURAL RECONSTRUCTION AND EVALUATION REPORT (Standard Accident Report)
Enclosure 9	CONTACT #131 AND #712 RECOVERED RH SRB AFT FIELD JOINT EVALUATION

SOLID ROCKET BOOSTER INCREMENTAL RECOVERY PLANNING

May 1, 1986

APPROVED: ______________________________
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Director, Structures and Propulsion Laboratory
NASA, Marshall Space Flight Center

SOLID ROCKET BOOSTER INCREMENTAL RECOVERY PLANNING

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SOLID ROCKET BOOSTER INCREMENTAL RECOVERY PLANNING

I. SCOPE AND INTRODUCTION

A. *SCOPE*

This section describes the recovery process form the initial planning and identification of Solid Rocket Booster (SRB) components and coordination with the Navy salvage operations through the recovery to the placement of hardware in Hangar "O" or the Explosive Ordnance Disposal (EOD) Range for evaluation. The recovery operation was initiated by searching areas defined by radar tracks provided by the Eastern Space and Missile Center (ESMC) Range Safety organization with use of sonar devices. Sonar contacts were then investigated by manned or unmanned submersibles to determine if the contacts were hardware from the 51-L vehicle and to obtain video/photograhic/audio records for further identification by personnel on shore. Once hardware was determined to be useful to the investigation, plans were generated to recover and transport to shore. Safing operations (propellant disposal) and more definition of the hardware dimensions, features, etc. were then conducted for storage/other evaluation. All recovered hardware has a contact number assigned individually to catalogue each part. For the purpose of consistency, reference to SRB hardware will be by contact number with the control numbers listed in Appendix A of the Search, Recovery, and Reconstruction Team Report. The control numbers and documentation were established by the 51-L Debris Impound Area Group.

B. *INTRODUCTION*

The SRB Recovery Support Team was established to aid in identifying hardware located by the search vehicles. This was accomplished by placing personnel who were knowledgeable of the Shuttle hardware on-board the search vessels for initial identification (SRB, Left Hand, Right Hand, External Tank, etc.) and by subsequent review of underwater examination records by personnel on shore. Personnel from NASA, Morton Thiokol, Inc. (MTI), USBI Booster Production Co., Inc. (USBI), and Lockheed Space Operations Company (LSOC) served on-board the search and recovery vessels. The support personnel on-board the salvage vessel (Stena Workhorse), including representatives from the ESMC Explosive Ordnance Disposal (EOD) organization, assisted in the salvage operations to ensure safety, hardware preservation, and to maintain evidence of flight anomalies.

Team members also supported the Navy Superintendent of Salvage (SUPSALV) in determining areas for search and priorities for recovery operations. Analysis of telemetry data on 51-L SRB's provided data that the right-hand motor was anomalous. In addition, early photographic and video tracking film evaluation identified the right-hand SRB as having problems. The Task Force therefore declared priorities on the Space Shuttle recovery operations to retrieve the right-hand (RH) SRB, left-hand (LH) SRB, and Orbiter to assist in the accident analysis. Attention was given to the LH SRB for the purpose of obtaining additional information to aid in the evaluation of both factory and field joint performance. In addition to the SRB components, emphasis was given to the recovery of the Orbiter, External Tank (ET), and payload (Inertial Upper Stage (IUS), Tracking and Data Relay Satellite (TDRS)).

Other activities included providing daily status reports to 51-L Investigation Team personnel at MSFC and others (Commission Task Force, news media, etc.). After recovery, team members performed inspections and documented their findings to provide accurate descriptions of the hardware.

The following paragraphs provide a report of the recovery activities performed and document the results of the SRB hardware search and recovery operations.

II. DESCRIPTION OF SRB

A. *GENERAL*

In order to understand the SRB terminology, an understanding of the components assembled on the vehicle is needed. The maneuvers of roll, pitch, and yaw are about the x, y, and z axes, respectively (reference Figure 1). Sitting in the Orbiter and looking forward, the RH SRB is below and to the right. The RH SRB is a mirror image of the LH SRB, therefore, reference datums in addition to the x, y, and z axes were established to maintain uniformity. The zero degree datum for the LH SRB is on the upper center line (+ z axis), and the zero degree datum for the RH SRB is on the lower center line (-z axis).

An SRB is nominally 12 feet in diameter and 149 feet long. The inert weight is 175,000 pounds, and the lift-off weight is 1,300,000 pounds. The SRB system provides the necessary structural support for the Shuttle vehicle on the launch pad, transfers thrust loads to the Orbiter and ET, and provides housing, structural support, and bracketry needed for the recovery system, the electrical components, the separation motors, and the Thrust Vector Control (TVC) system. The SRB systems consist of the forward assembly (forward skirt, frustum, and nose cap), the Solid Rocket Motors (SRM's), and the aft skirt assembly. SRB structural components are planned to be used for 20 flights (reference Figure 2).

Documentation convention stipulates that all vehicles are drawn going from the left (forward) to right (aft) thereby presenting the LH side of the vehicle. Consequently, only the LH SRB is documented; therefore, care must be exercised in reviewing drawings and illustrations to distinguish the RH SRB for the LH SRB.

B. *SRB SYSTEMS*

1. *Forward Assembly.* —The forward assembly consists of the nose assembly, forward ordnance ring, and forward skirt.

a. *Nose Assembly*—The nose assembly includes the nose cap, the frustum structure, the frustum flotation components, and hardware for attaching the forward separation motors and nose cap thrusters. The nose cap houses both the pilot and drogue parachutes and is separated in-flight from the frustum by three nose cap thrusters. The frustum houses the main parachutes and altitude sensor assembly, provides the structural support for the forward separation motors, and incorporates flotation devices and handling hardware for water recovery.

b. *Forward Ordnance Ring*—The forward ordnance ring provides a plane of separation between the frustum and the forward skirt assembly. The ring houses the linear-shaped charge (LSC) used in the destruct function.

c. *Forward Skirt*—The forward skirt is comprised of an SRB/ET attachment fitting which transfers the thrust loads from the SRB to the ET. The forward skirt also has a forward bulkhead which seals the forward end of the skirt. The skirt provides the structure to react parachute loads during deployment, descent and towing. Internal structures are provided for mounting components of the electrical and instrumentation (E&I) subsystem, the rate gyro assembly, range safety panels, and the systems tunnel components. The skirt assembly, at completion of installation, is sealed to provide additional flotation capability.

2. *Solid Rocket Motor (SRM)*:

a. *Solid Rocket Motor*—The SRM is the primary propulsive element for the Space Shuttle providing 563.5 pounds per square inch absolute chamber pressure which is equal to 1.9 million pounds of thrust vacuum. The SRM consists of: an insulated and lined segmented rocket motor case loaded with solid propellant; an ignition system complete with electromechanical safe and arm device, initiator, and loaded igniter; a movable nozzle; raceway bracketry; instrumentation; and the necessary integration hardware.

b. *Structural*—The major configurations required to assemble one SRM are a forward rocket motor segment, two center rocket

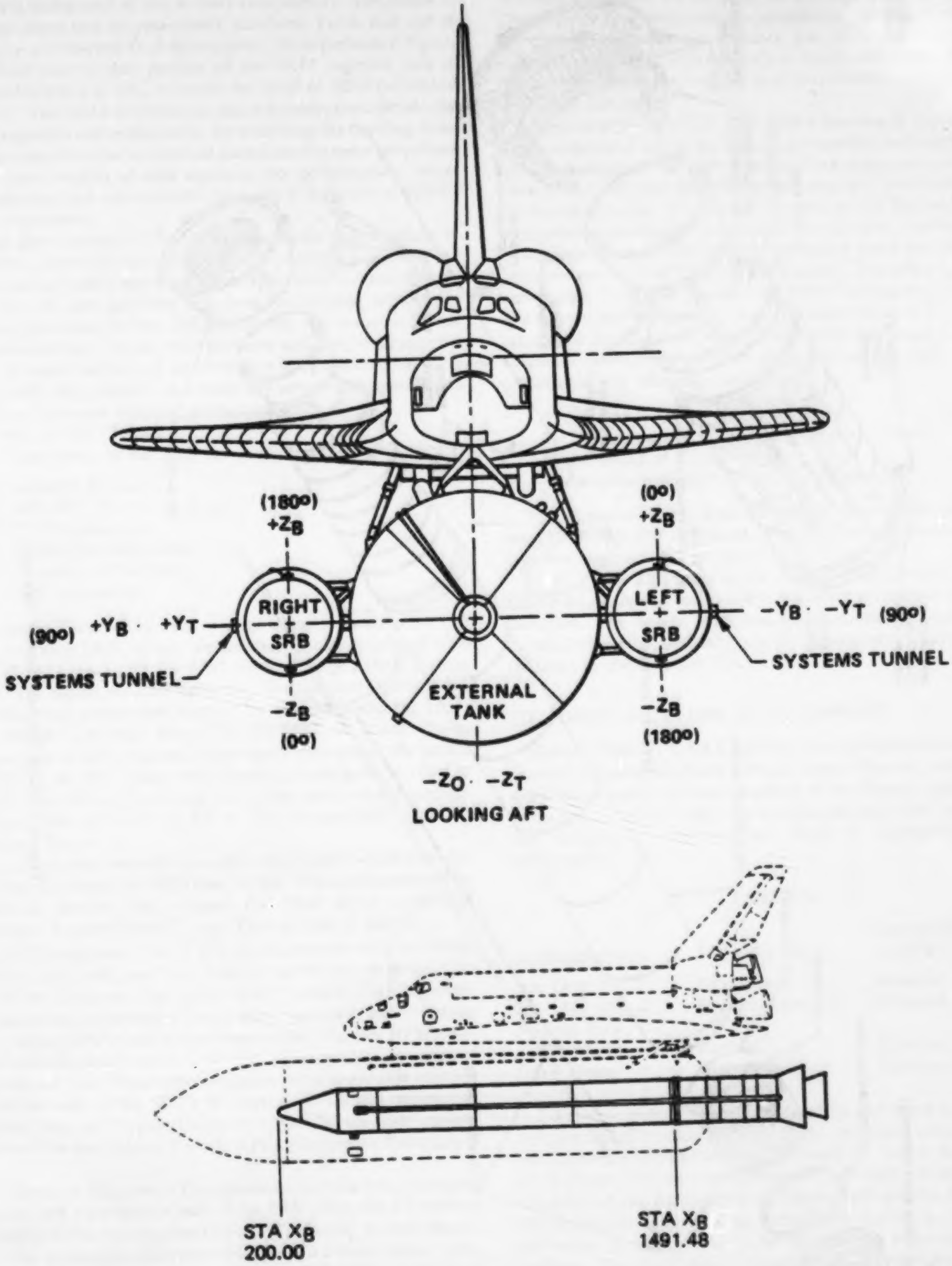

(180°)
+ZB
(0°)
+ZB
RIGHT
SRB
LEFT
SRB
(90°) +YB · +YT
-YB · -YT (90°)
SYSTEMS TUNNEL
SYSTEMS TUNNEL
EXTERNAL
TANK
-ZB
(0°)
-ZB
(180°)
-ZO · -ZT
LOOKING AFT
STA XB
200.00
STA XB
1491.48

Figure 1. 51-L Coordination System

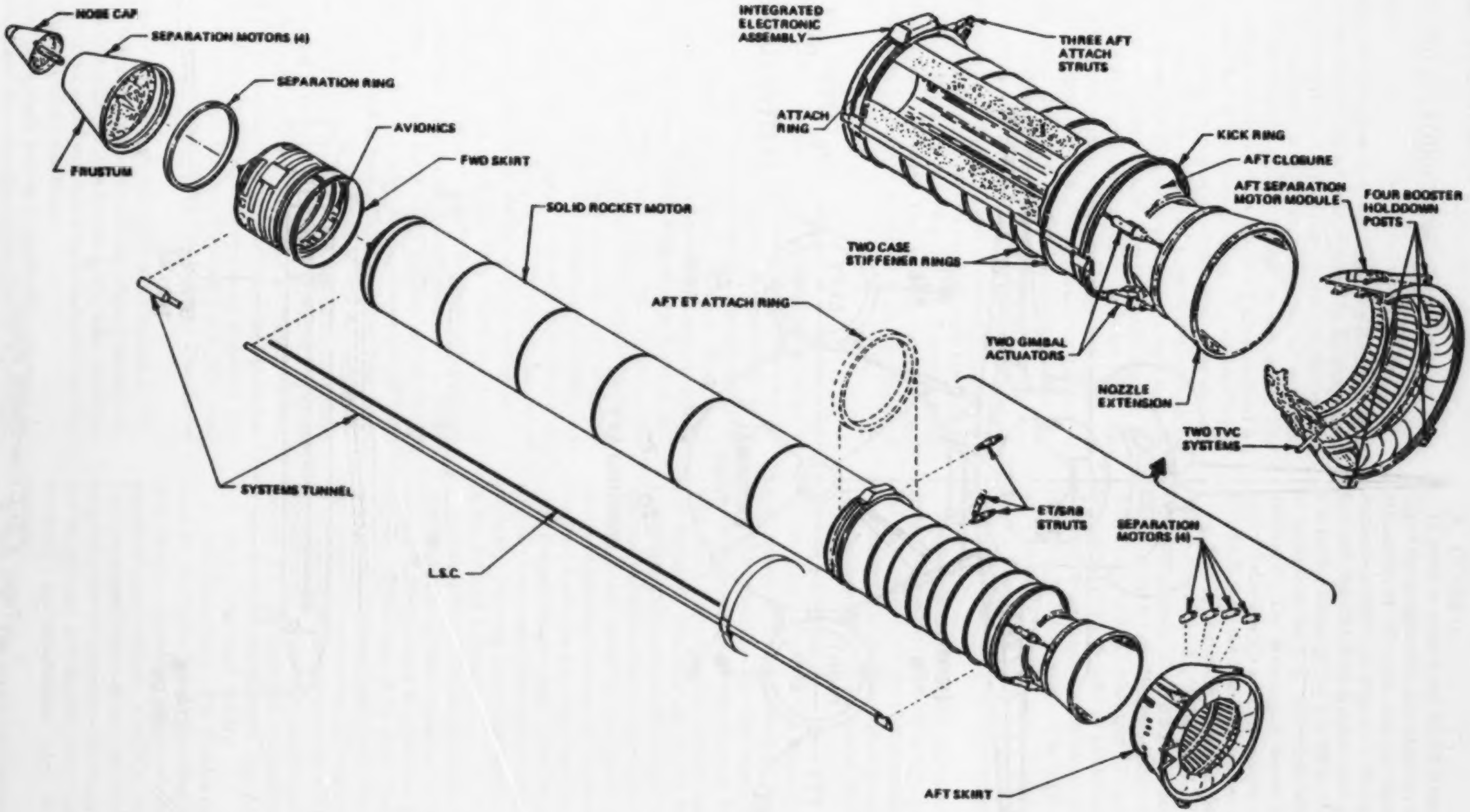

NOSE CAP
SEPARATION MOTORS (4)
SEPARATION RING
FRUSTUM
AVIONICS
FWD SKIRT
SOLID ROCKET MOTOR
SYSTEMS TUNNEL
L.S.C.
AFT ET ATTACH RING
ET/SRB STRUTS
SEPARATION MOTORS (4)
AFT SKIRT
INTEGRATED ELECTRONIC ASSEMBLY
THREE AFT ATTACH STRUTS
ATTACH RING
KICK RING
AFT CLOSURE
AFT SEPARATION MOTOR MODULE
FOUR BOOSTER HOLDDOWN POSTS
TWO CASE STIFFENER RINGS
TWO GIMBAL ACTUATORS
NOZZLE EXTENSION
TWO TVC SYSTEMS

Figure 2. Solid Rocket Booster Structure

motor segments, and one aft rocket motor segment. Each SRM segment is comprised of two to four components. The joints of the components that are assembled, insulated, lined, and cast at the factory are referred to as factory/plant joints (reference Figure 3). A field joint is that portion of the SRM segment that is assembled/stacked at KSC to create the finished SRM (reference Figure 4). The SRM components and subsystems are physically interchangeable and replaceable. By matching the burning rates of motor segments cast in matched pairs from the same propellant lot and case weights of each segment, the performance, interchangeability, and replaceability between a flight set of SRM's can be maintained.

3. *Aft Skirt Assembly*—The aft skirt provides attach points to the Mobile Launch Platform (MLP) and provides support to the Shuttle on the launch pad for all conditions prior to booster ignition. The aft skirt provides aerodynamic/thermal protection, mounting provisions for the TVC subsystem, and the aft mounted separation motors. The aft skirt provides sufficient clearance for the SRM nozzle at the null position plus full gimbal travel. The aft skirt kick ring provides the necessary structural capability to absorb and transfer induced pre-launch loads.

C. *SRB SUBSYSTEMS*

The subsystems of the SRB are made up of the following:

1) Systems Tunnel
2) SRB/ET Aft Attach Ring
3) TVC subsystem
4) Separation subsystem
5) Recovery subsystem
6) E&I subsystem.

1. *Systems Tunnel*—The SRB systems tunnel, located at the 90° position of each SRB, houses the electrical cables associated with the E&I subsystem and the LSC of the Range Safety System (RSS). The tunnel provides lightning, thermal, and aerodynamic protection and mechanical support for the cables and the LSC.

2. *SRB/ET Aft Attach Ring*—The SRB/ET aft attach ring is composed of a steel ring and three struts that physically attach the SRB to the ET. These attachments are designed to react to loads in place of the attach ring and allow unrestrained contraction/expansion of SRB or ET in the longitudinal direction (reference Figure 5).

The attach strut assembly provides the physical attachment between the aft ring of the SRB and the ET. The strut incorporates separation devices that release the SRB upon command (references Figures 6 and 7, and Photographs 1 and 2).

3. *TVC Subsystems*—The TVC, in conjunction with the SRM, provides pitch, roll, and yaw vehicle movements as desired by the Orbiter Guidance, Navigation and Control (GN&C) System. The subsystem, mounted in the aft skirt, consists of two hydraulic power units (HPU's) and two servoactuators. The two HPU's provide hydraulic power to drive the two servoactuators, designated as Rock and Tilt. These servoactuators serve to provide attitude control for each of the SRB's in response to control commands from the General Purpose Computers (GPC's) via flight control electronics in the Orbiter Vehicle (OV). (Reference Photograph 3.)

4. *Separation Subsystem*—The separation subsystem is designed to ensure safe separation of each of the SRB's from the ET without damaging or recontacting the Orbiter/ET during or after separation. The separation subsystem consists of a release system, sensors, and separation bolts located in the SRB/ET foward attach fitting and in each of the aft attach struts, and eight solid booster separation motors (BSM's)—four mounted in the SRB nose frustum and four mounted externally on the aft skirt. The aft motors are located unsymmetrically, which causes a small roll movement to be imparted to the SRB. The BSM's are located such that the SRB moves from the Orbiter/ET in a way that reduces the plume and particle impingement on the Orbiter. All sequencing and commands are issued by the Orbiter.

5. *Recovery Subsystem*—The booster recovery subsystem provides the necessary hardware to control the SRB final descent velocity and attitude after separation. The major components of the recovery subsystem are the pilot, drogue and main parachutes. The recovery subsystem includes parachutes, methods of sequencing and deploying these parachutes, parachute separation components, and location aids that help in search and retrieval operations for the expended booster and parachutes.

6. *E&I Subsystem*:

a. *Operational System:* The SRB E&I subsystem for operational flights consists of two major functional systems dedicated to two specific portions of the SRB mission. One system is operational from prelaunch until SRB/ET separation and is referred to as the Ascent System. This system consists of the E&I subsystem components necessary to respond to Orbiter vehicle (OV) commands for controlling SRB prelaunch functions, ignition, powered ascent, and SRB/ET monitored. The other system is operational from just prior to SRB/ET separation until SRB splashdown and is referred to as the Recovery System. This system consists of the E&I subsystem components that bring about the successful recovery of the SRB after burnout and separation by performing the following functions:

1) Severance of the nozzle extension
2) Deployment of the drogue and main chutes
3) Powering of location aids
4) Severance of main chute at water impact

The recovery system is simple and self-contained, except for initial POWER ON command, which is derived from the separation fire commands from the OV.

b. *RSS:* The RSS contains the necessary equipment to destroy the SRB in case of a malfunction requiring premature flight termination. The system is ground operated and redundant. It is monitored, tested, and safed via the Multiplexer-Demultiplexer (MDM) in the forward IEA.

III. IDENTIFICATION OF HARDWARE

Shuttle Flight 51-L SRB hardware was initially located on the ocean floor using the Klein sidescan sonar. Search patterns were established based on radar tracking of the Shuttle components. Identification of the sonar contacts was accomplished by manned and unmanned submersibles. Table I summarizes these submersibles.

TABLE I

SUBMERSIBLE	*TENDER SHIP*	*MANNED/ UNMANNED*
Sea Link JSL I	Edwin Link	Manned
Sea Link JSL II	Seward Johnson	Manned
Nuclear Sub NR-1	Sunbird	Manned
Deep Drone	Independence	Unmanned

Contractor and/or National Aeronautics and Space Administration personnel familiar with the flight hardware were on-board the manned submersibles and on-board the tender ship for the Deep Drone. The on-board personnel provided immediate identification of the hardware and pointed out specific identifying characteristics (clevis, tang, serial/part numbers, propellant thickness, inhibitor, etc.) to be recorded on video and photographed. The color video with audio and photographs made on-board the submersibles (no audio with Deep Drone) were then sent ashore for developing, duplicating, and further identification.

A. *METHOD OF IDENTIFICATION*

As an aid to hardware identification, books containing photographs and illustrations of identifying characteristics were compiled and distributed to team personnel on-board recovery vessels.

The assets used to identify SRB hardware during the search operation are listed below. Identification of parts determined as

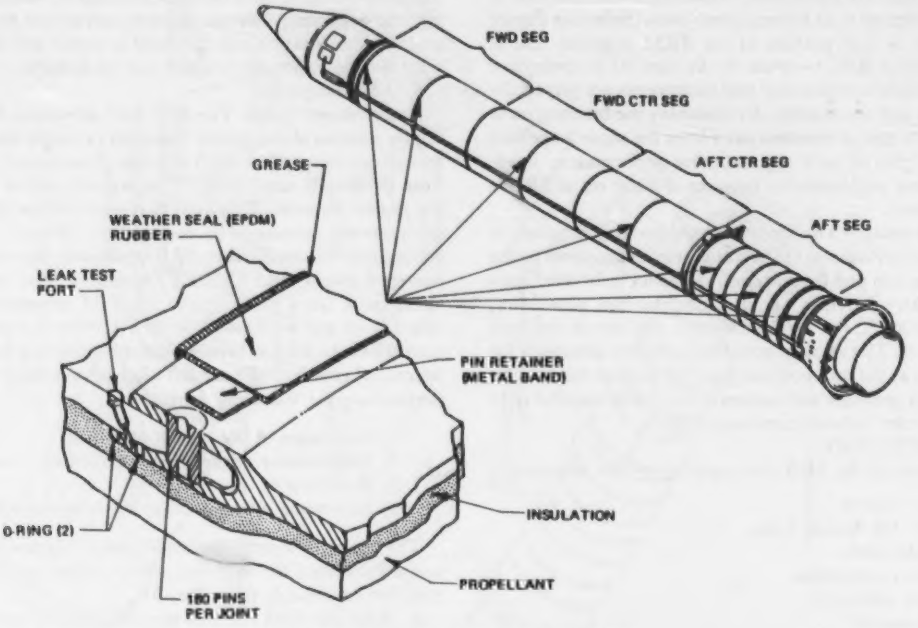

FWD SEG
FWD CTR SEG
AFT CTR SEG
AFT SEG
GREASE
WEATHER SEAL (EPDM) RUBBER
LEAK TEST PORT
PIN RETAINER (METAL BAND)
INSULATION
O-RING (2)
PROPELLANT
180 PINS PER JOINT

Figure 3. SRM Factory/Plant Joints

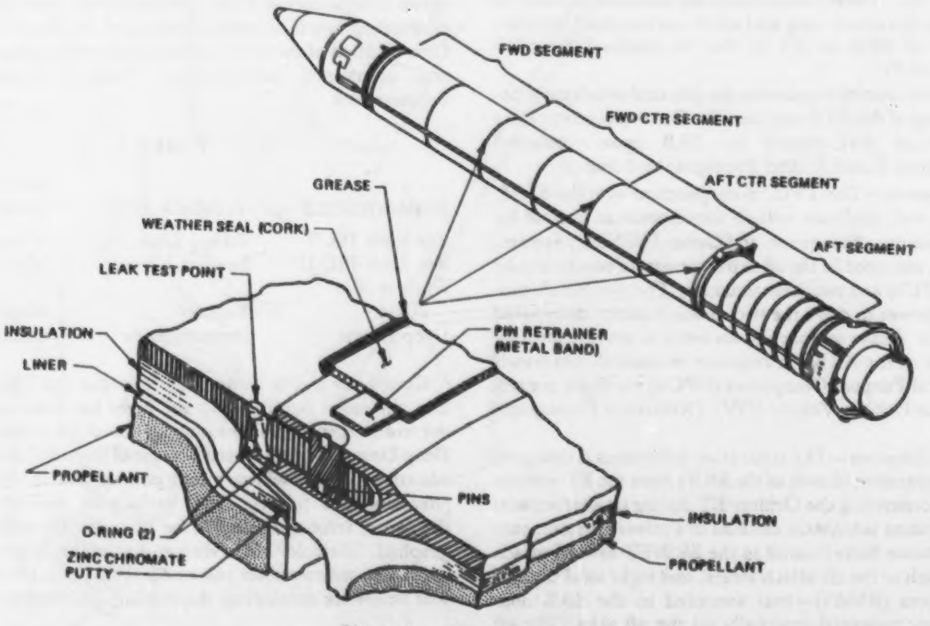

FWD SEGMENT
FWD CTR SEGMENT
AFT CTR SEGMENT
AFT SEGMENT
GREASE
WEATHER SEAL (CORK)
LEAK TEST POINT
INSULATION
LINER
PIN RETRAINER (METAL BAND)
PROPELLANT
PINS
INSULATION
PROPELLANT
O-RING (2)
ZINC CHROMATE PUTTY

Figure 4. SRM Field Joints

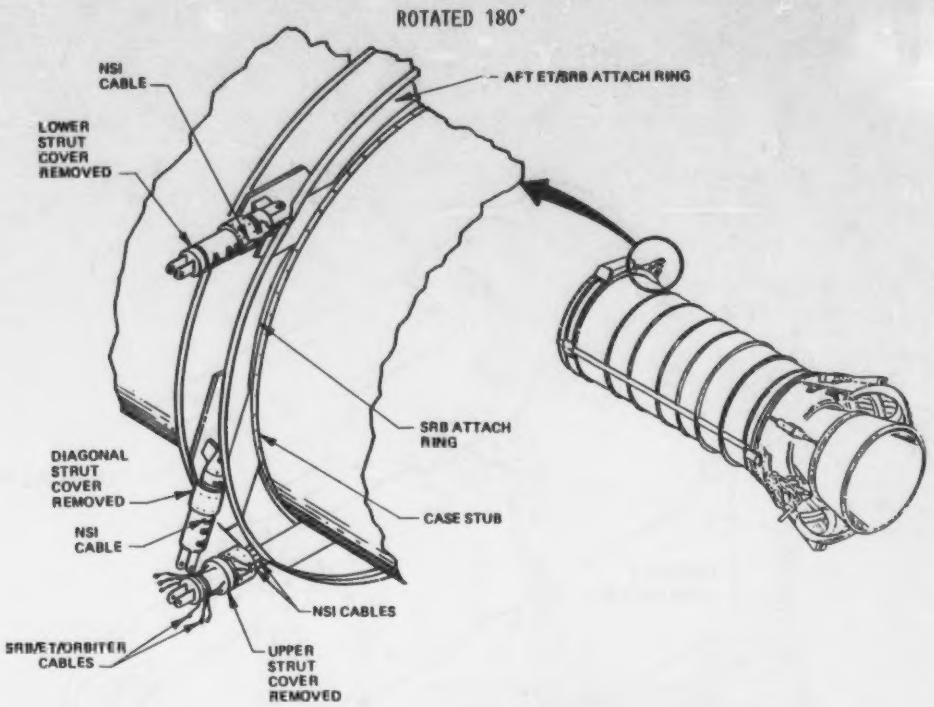

ROTATED 180°
NSI CABLE
AFT ET/SRB ATTACH RING
LOWER STRUT COVER REMOVED
SRB ATTACH RING
DIAGONAL STRUT COVER REMOVED
CASE STUB
NSI CABLE
NSI CABLES
SRB/ET/ORBITER CABLES
UPPER STRUT COVER REMOVED

Figure 5. SRB/ET Aft Attach Strut

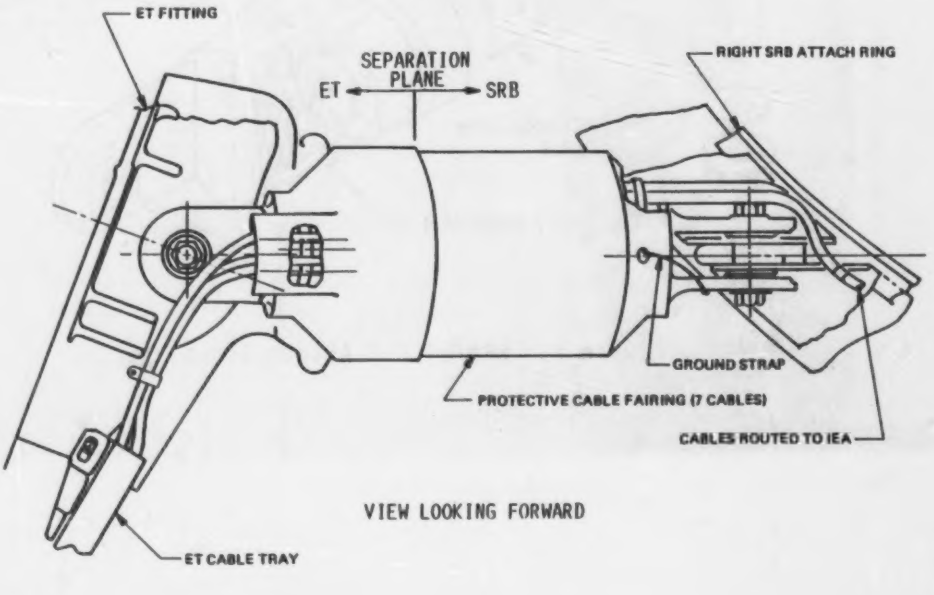

ET FITTING
SEPARATION PLANE
ET
SRB
RIGHT SRB ATTACH RING
GROUND STRAP
PROTECTIVE CABLE FAIRING (7 CABLES)
CABLES ROUTED TO IEA
VIEW LOOKING FORWARD
ET CABLE TRAY

Figure 6. SRB/ET Upper Strut Assembly (RH)

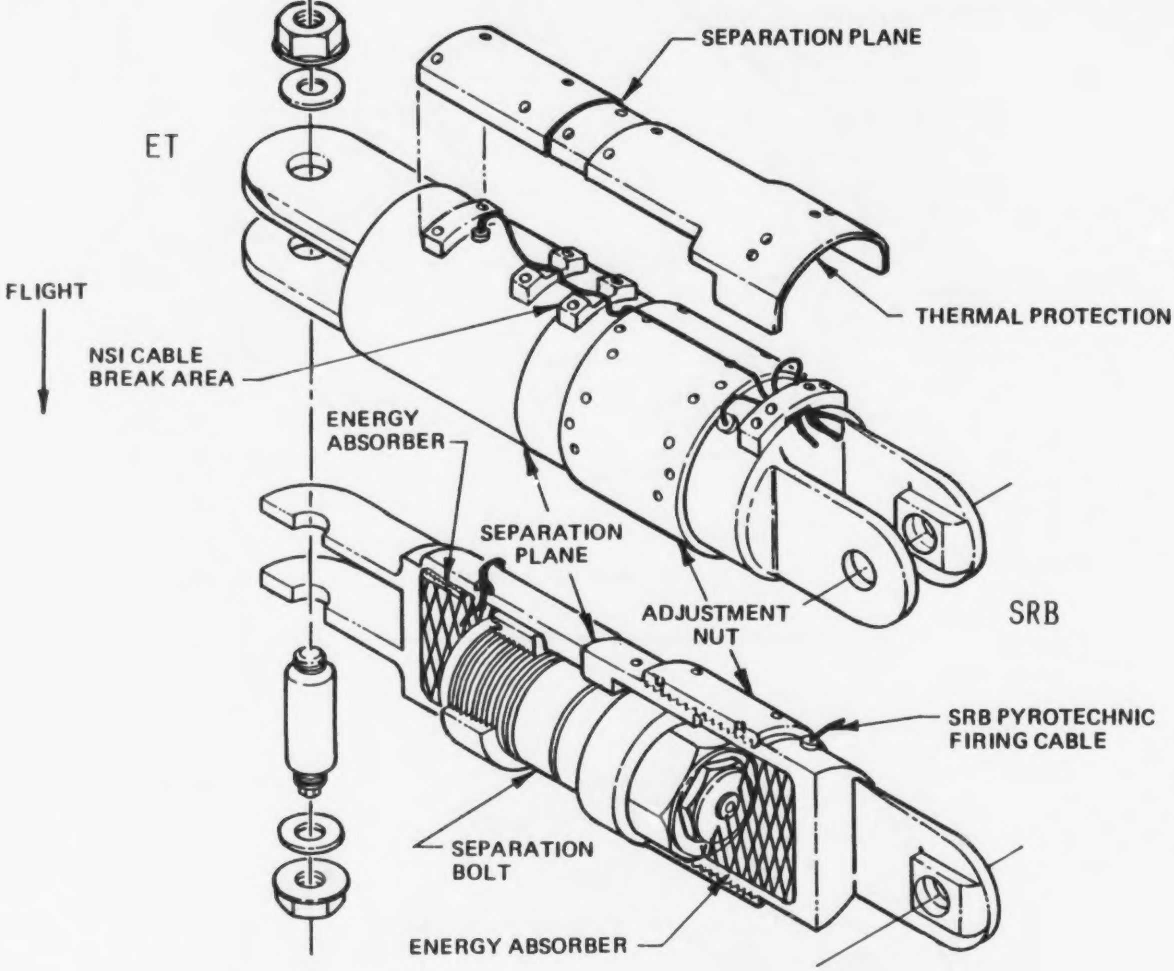
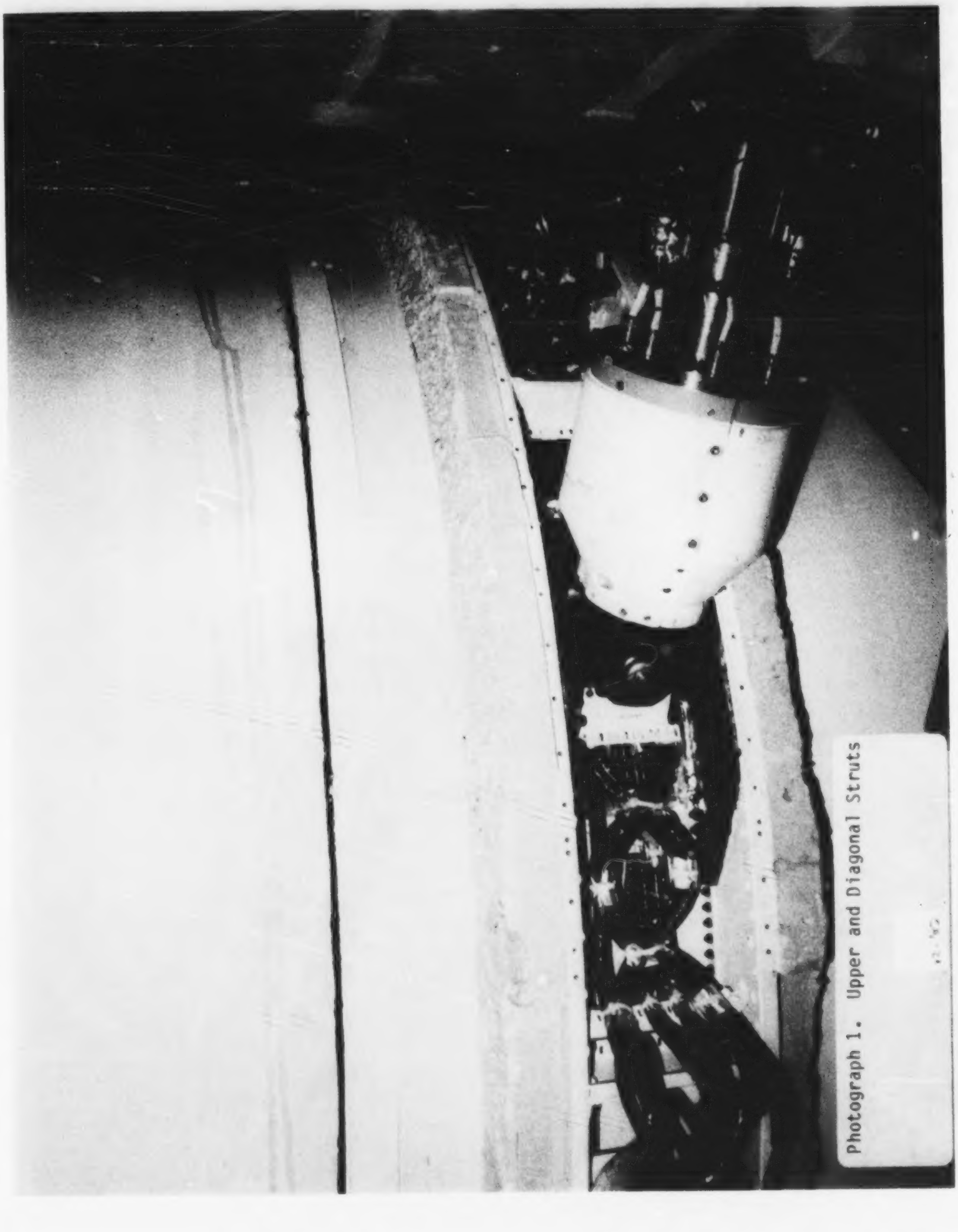
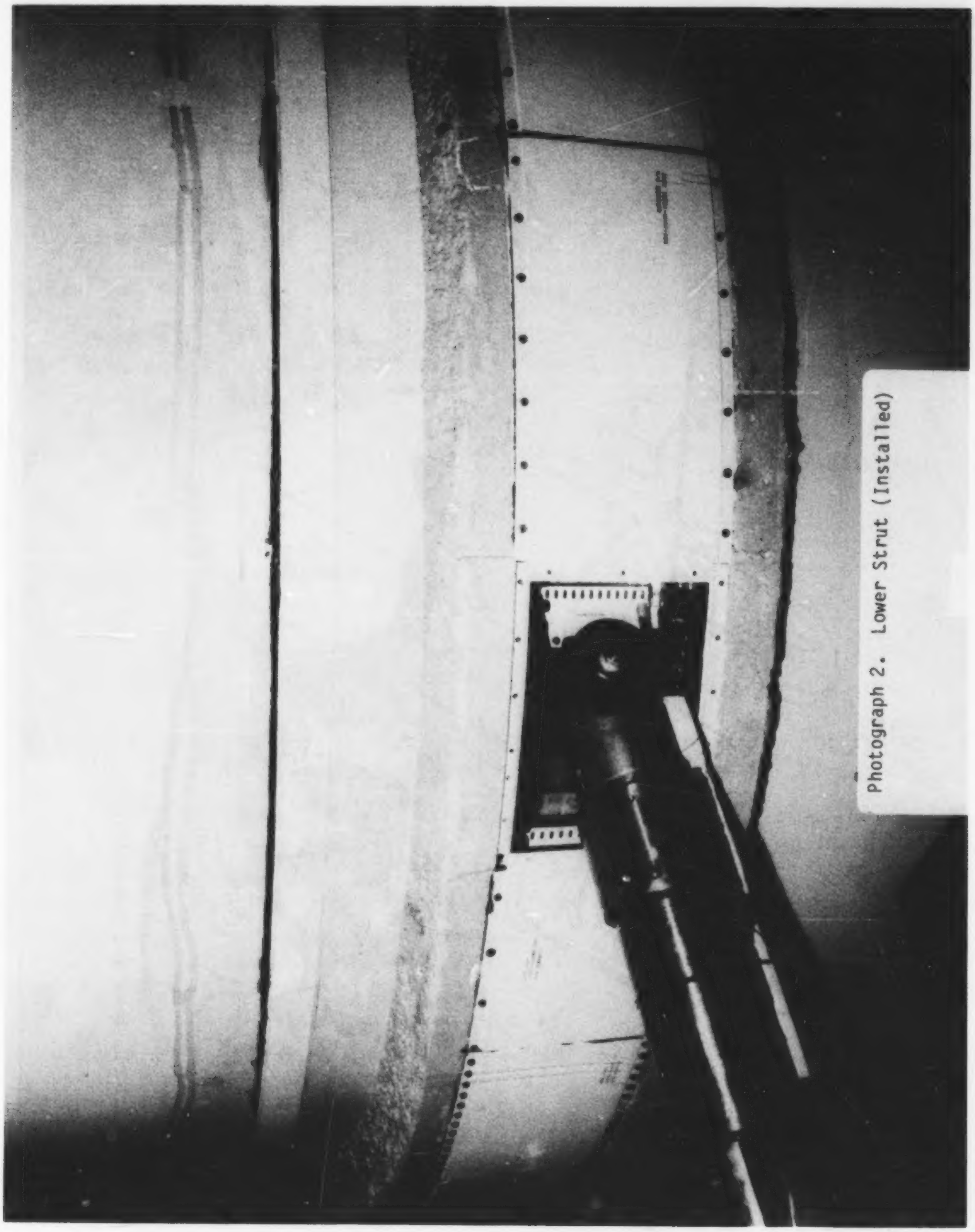

SEPARATION PLANE
ET
THERMAL PROTECTION
FLIGHT
NSI CABLE BREAK AREA
ENERGY ABSORBER
SEPARATION PLANE
ADJUSTMENT NUT
SRB
SRB PYROTECHNIC FIRING CABLE
SEPARATION BOLT
ENERGY ABSORBER

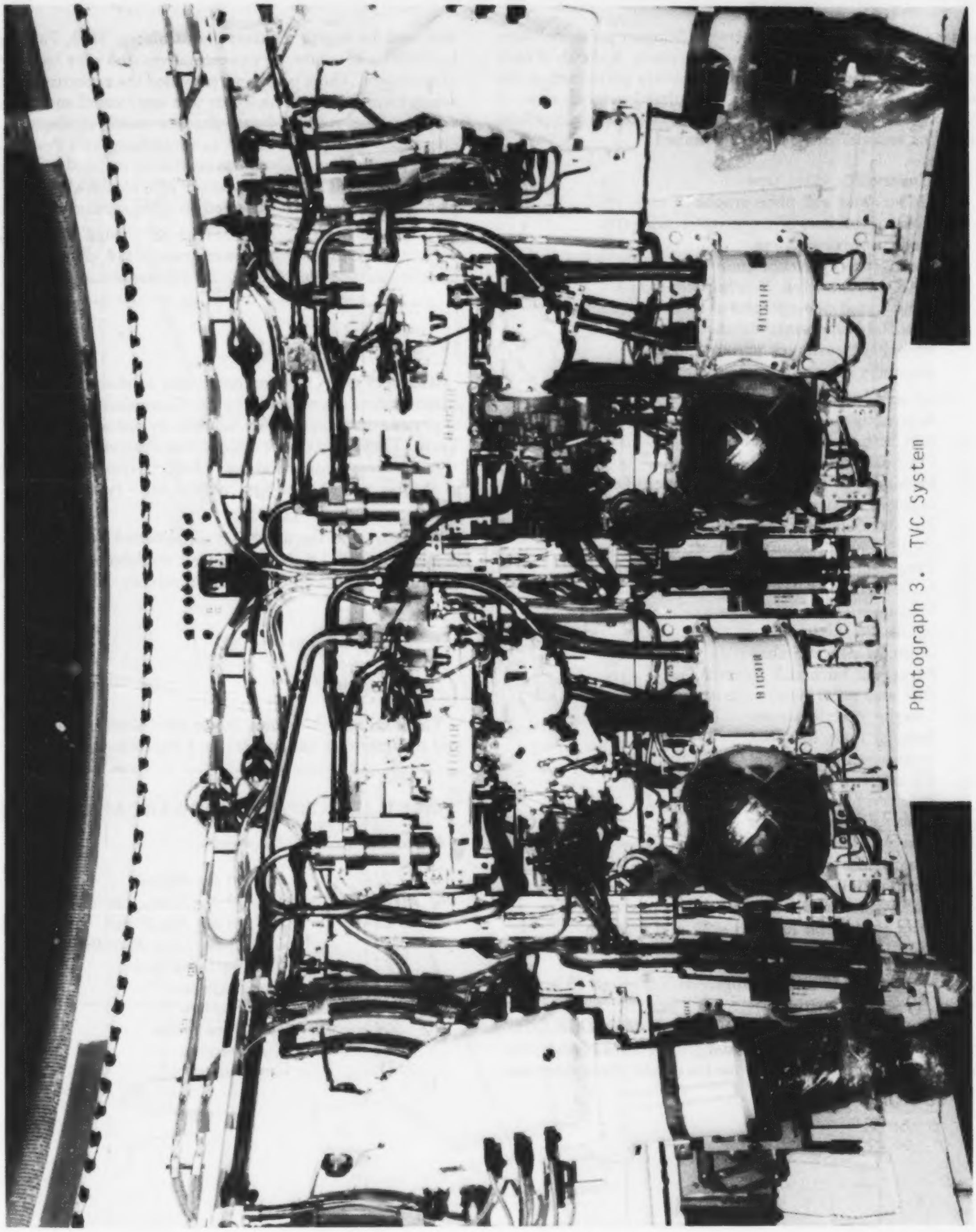
Figure 7. SRB/ET Aft Attach Strut



Photograph 1. Upper and Diagonal Struts



Photograph 2. Lower Strut (Installed)



Photograph 3. TVC System

important for recovery by the Recovery Support personnel were prioritized and forwarded to the salvage vessels. A sketch of each piece of hardware was made to assist recovery personnel on the ships to identify attachment points. Calculated weight, center of gravity (c.g.), dimensions, and special notes concerning propellant locations or areas of caution were included.

1. *Assets*
   - a) Underwater video tape
   - b) Underwater still photographs
   - c) Artist renditions of underwater artifacts
   - d) Radar trajectory plots
   - e) Sonar cross reference charts
   - f) NASA Select Press Briefing video tape
   - g) Land based photographs of recovered hardware
   - h) Assembly blueprints/sketches
   - i) Propellant burnback pattern charts
   - j) Assembly close-out photographs
2. *Identifying Characteristics*
   - a) Inherently unique pieces
   - b) Bolt hole sizes (ET stub ring)
   - c) Pin hole sizes (clevis)
   - d) Proximity of known hardware (identified pieces to adjacent unidentified pieces)
   - e) Pin and bolt hole locations
   - f) Type of joint (factory or field, tang or clevis)
   - g) Tang index slots (at 0, 118, and 240 degrees)
   - h) Leak check port location (at 0 degree on tang)
   - i) Insulation configuration
   - j) Insulation thickness
   - k) Inhibitor size and shape
   - l) Propellant burnback pattern
   - m) Part and serial number markings (where available)
   - n) Exterior cork locations
   - o) Exterior foam locations
   - p) System tunnel remnants
   - q) ET attach remnants
   - r) Stub remnants for ET attach ring
   - s) Stiffener ring remnants
   - t) Case wall discoloration patterns
   - u) Comparison of radar trajectory track to sonar location (latitude and longitude)
   - v) Scaling known dimensions as a comparison base
   - w) Paint pattern on forward skirt and frustum
   - x) BSM location

Figures 8 through 12 and Photographs 4 through 13 are examples of identifying methods.

B. *ANALYSIS OF VIDEO, AUDIO, AND PHOTOGRAPHS*

Video, audio (where provided), and photographs of each contact were analyzed to help identify the hardware. Each video was analyzed for Shuttle element (i.e., Orbiter, SRB, Payload, etc.) by NASA and contractor representatives who were knowledgeable of hardware. These personnel provided the expertise required to assure identification of hardware that was located and filmed. Personnel who served on-board the sea vessels during the search operations also provided aid in identifying and describing the hardware. further analysis was conducted on hardware identified as part of the SRB flight element to provide data for the recovery plan. A list of hardware observed on video is listed in Appendix A.

C. *HARDWARE IDENTIFIED BUT NOT RECOVERED*

During the investigation, hardware of low value to the failure investigation was identified but not recovered and is listed in Table II.

IV. RECOVERY PLANS

Recovery plans were prepared and used as a means to obtain authorization for recovery by the Commission Task Force and to provide the requirements for recovery operations to the Salvage Team. These plans were defined based upon hardware criticality to the investigation and safety hazards (primarily to fishermen in shallow water). See Appendix B for a typical plan.

A. *RECOVERY ASSETS*

Assets used in the operation were owned by NASA or owned or leased by the U.S. Navy and were classified into four categories according to task assignment and capability. The categories were:

1) Search
2) Identification
3) Recovery
4) Logistics

Table III identifies each major asset used by the Task Force and includes task assignment and capabilities of each element.

TABLE II. IDENTIFIED HARDWARE NOT RECOVERED

Contact Number	*Description*
21-6	*RH Aft Seg Stiffener*
21-7	*RH Aft Seg Nozzle Part*
21-8	*RH Aft Seg Nozzle Part*
24	*LH Aft Seg/Dome/Kick Ring*
41	*Fwd Seg/Dome/Igniter*
345	*Case Fragment*
417	*Case Fragment*
504	*Fwd Dome/Igniter*
632	*Case Fragment*
5125	*Case Fragment (?)*

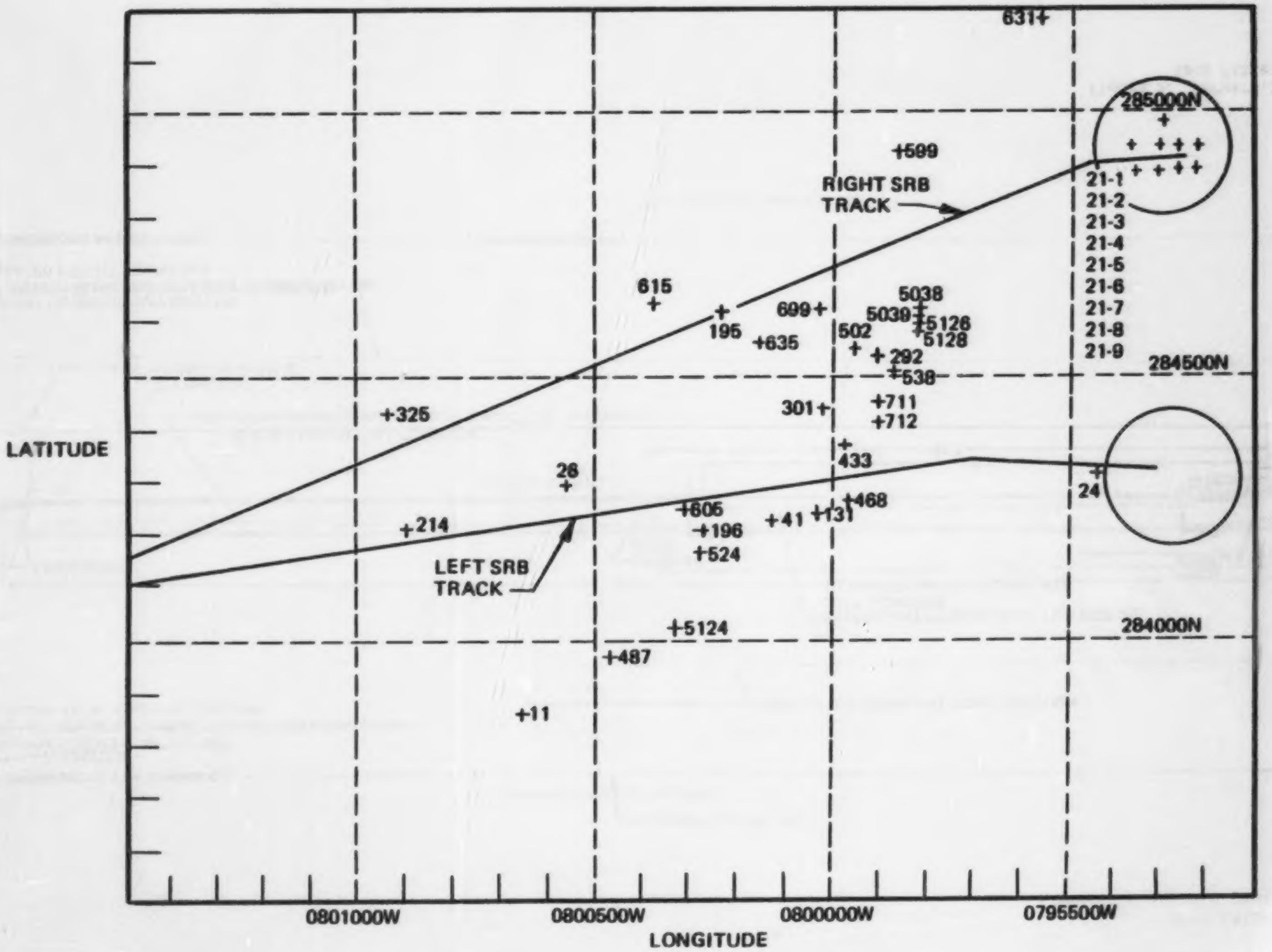
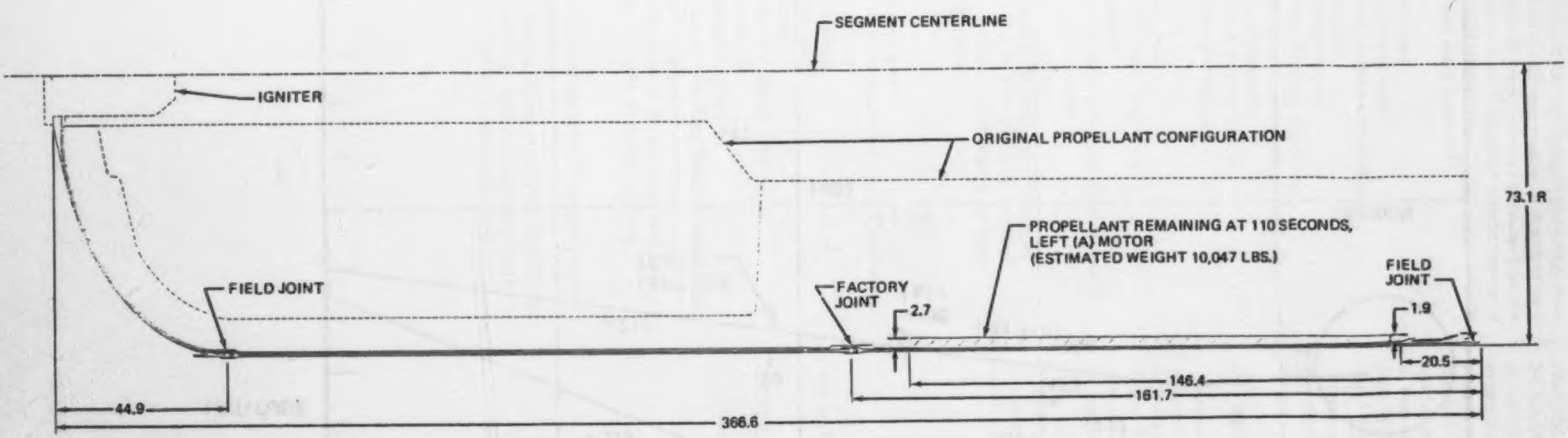


Figure 8. Radar Trajectory Plot

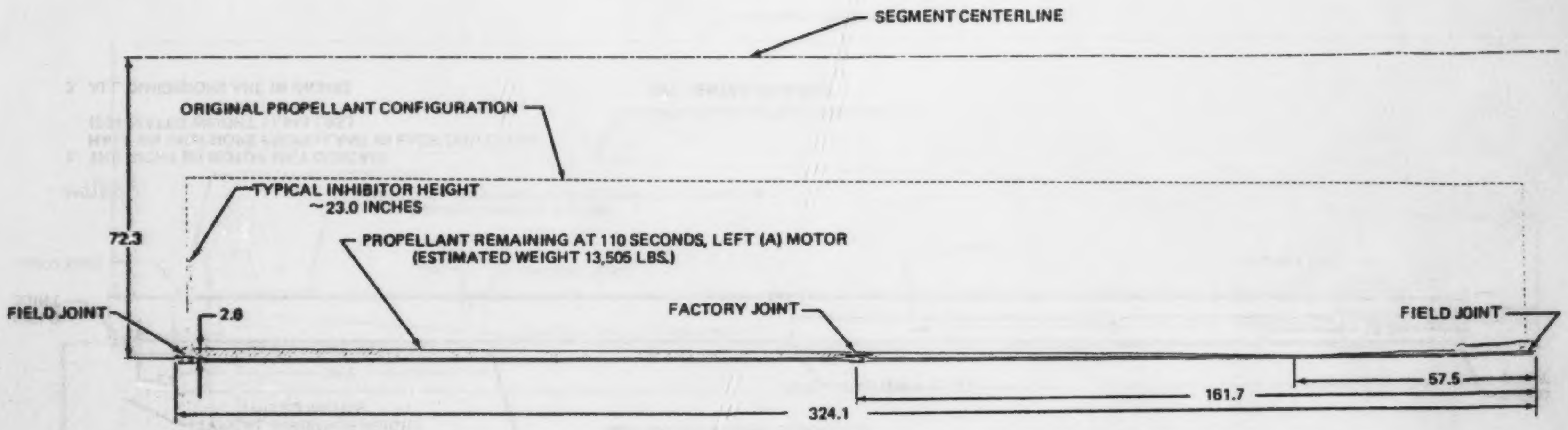

SEGMENT CENTERLINE
IGNITER
ORIGINAL PROPELLANT CONFIGURATION
73.1 R
PROPELLANT REMAINING AT 110 SECONDS, LEFT (A) MOTOR (ESTIMATED WEIGHT 10,047 LBS.)
FIELD JOINT
FACTORY JOINT
2.7
FIELD JOINT
1.9
20.5
146.4
161.7
44.9
366.6

NOTES:

1. THE RIGHT (B) MOTOR MAY CONTAIN HALF AN INCH MORE PROPELLANT IN EACH DIRECTION (ESTIMATED WEIGHT 11,035 LBS.)
2. ALL DIMENSIONS ARE IN INCHES

FORWARD SEGMENT

Figure 9. Forward Segment Burn Back Pattern


SEGMENT CENTERLINE
ORIGINAL PROPELLANT CONFIGURATION
TYPICAL INHIBITOR HEIGHT
~23.0 INCHES
72.3
PROPELLANT REMAINING AT 110 SECONDS, LEFT (A) MOTOR
(ESTIMATED WEIGHT 13,505 LBS.)
FIELD JOINT
2.6
FACTORY JOINT
FIELD JOINT
57.5
161.7
324.1

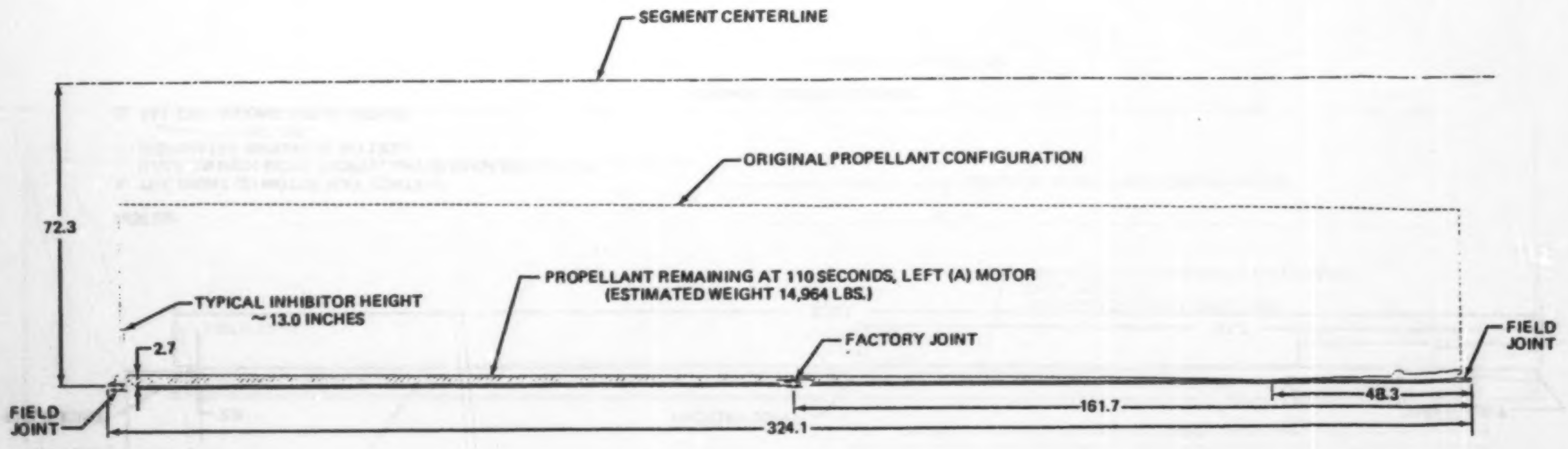
NOTES:

1. THE RIGHT (B) MOTOR MAY CONTAIN HALF AN INCH MORE PROPELLANT IN EACH DIRECTION (ESTIMATED WEIGHT 16,247 LBS.)

2. ALL DIMENSIONS ARE IN INCHES

FORWARD CENTER SEGMENT

Figure 10. Forward Center Segment Back Pattern

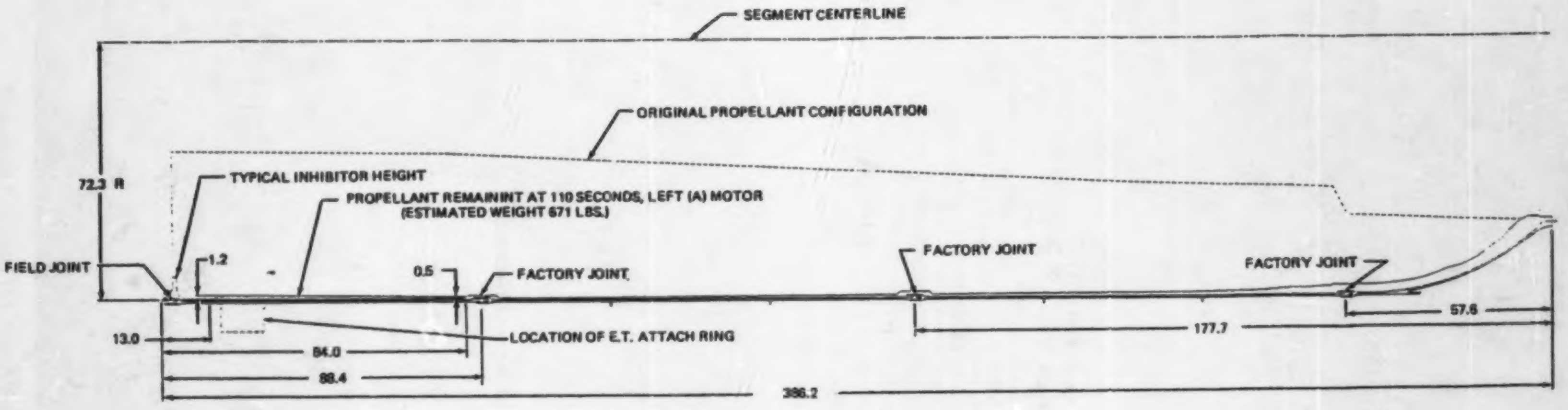

SEGMENT CENTERLINE
ORIGINAL PROPELLANT CONFIGURATION
72.3
PROPELLANT REMAINING AT 110 SECONDS, LEFT (A) MOTOR
(ESTIMATED WEIGHT 14,964 LBS.)
TYPICAL INHIBITOR HEIGHT
~ 13.0 INCHES
2.7
FACTORY JOINT
FIELD JOINT
FIELD JOINT
48.3
161.7
324.1

NOTES:

1. THE RIGHT (B) MOTOR MAY CONTAIN HALF AN INCH MORE PROPELLANT IN EACH DIRECTION (ESTIMATED WEIGHT 17,643 LBS.)
2. ALL DIMENSIONS ARE IN INCHES

AFT CENTER SEGMENT

Figure 11. Aft Center Segment Burn Back Pattern

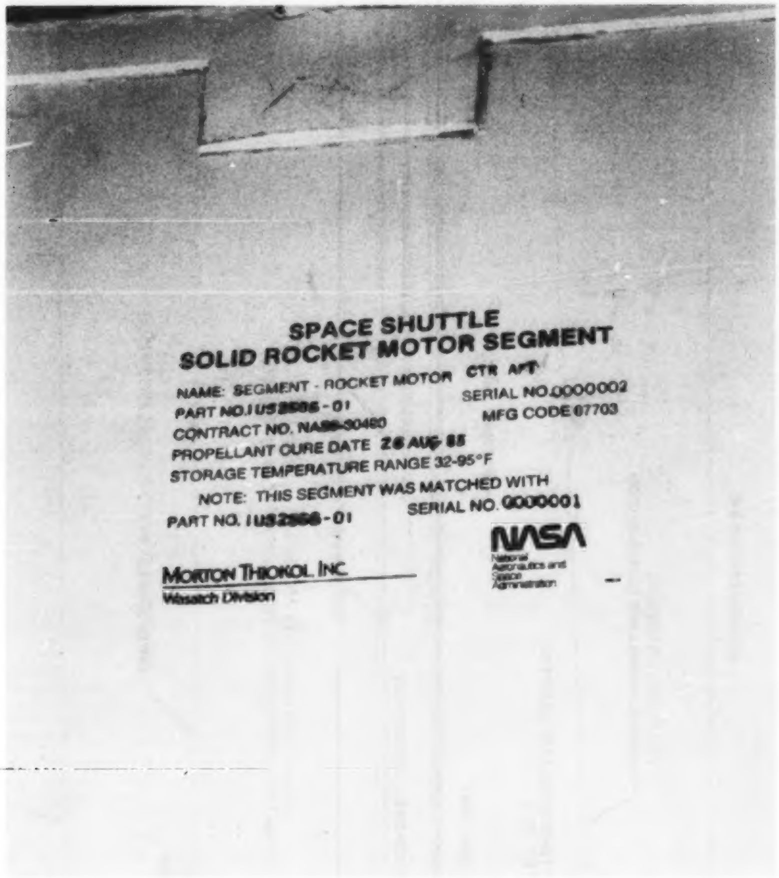

SEGMENT CENTERLINE
ORIGINAL PROPELLANT CONFIGURATION
72.3 R
TYPICAL INHIBITOR HEIGHT
PROPELLANT REMAININT AT 110 SECONDS, LEFT (A) MOTOR (ESTIMATED WEIGHT 671 LBS.)
FIELD JOINT
1.2
0.5
FACTORY JOINT
FACTORY JOINT
FACTORY JOINT
LOCATION OF E.T. ATTACH RING
13.0
84.0
88.4
57.6
177.7
386.2

NOTES:

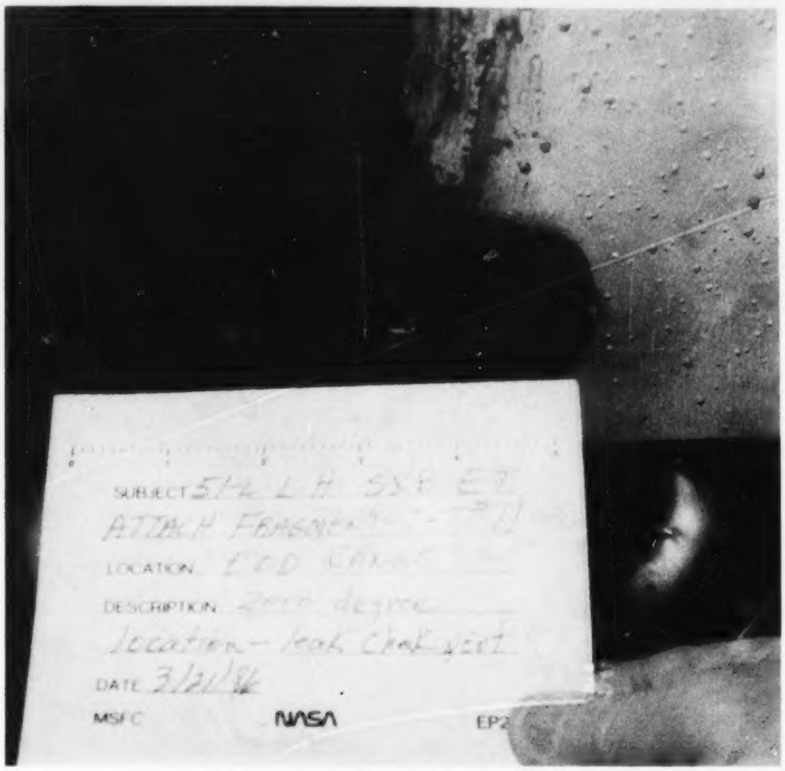
1. THE RIGHT (B) MOTOR MAY CONTAIN HALF AN INCH MORE PROPELLANT IN EACH DIRECTION (ESTIMATED WEIGHT 1,501 LBS.)
2. ALL DIMENSIONS ARE IN INCHES

AFT SEGMENT

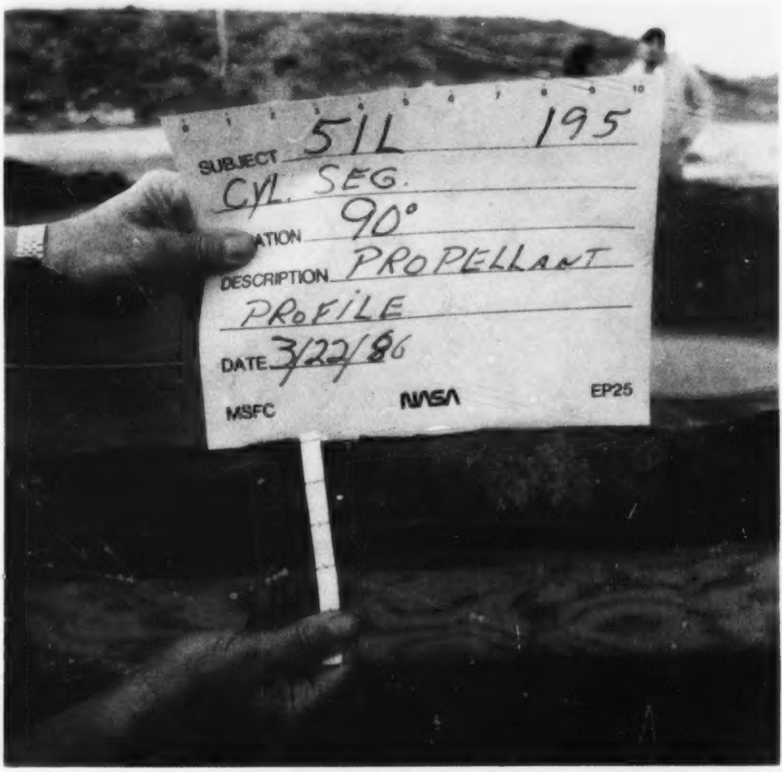
Figure 12. Aft Segment Burn Back Pattern


SPACE SHUTTLE
SOLID ROCKET MOTOR SEGMENT
NAME: SEGMENT - ROCKET MOTOR CTR AFT
SERIAL NO. 0000002
PART NO. 1U52586-01
MFG CODE 07703
CONTRACT NO. NAS8-30490
PROPELLANT CURE DATE 26 AUG 85
STORAGE TEMPERATURE RANGE 32-95°F
NOTE: THIS SEGMENT WAS MATCHED WITH
PART NO. 1U52566-01
SERIAL NO. 0000001
NASA
National Aeronautics and Space Administration
MORTON THIOKOL INC
Wasatch Division

Photograph 4. SRM Segment Nameplate


SUBJECT
LOCATION
DESCRIPTION Zero degree
location – leak check port
DATE 3/21/86
MSFC
NASA
EP2

Photograph 5. Contact 26-1, SRM LH Aft Segment, Pressure Port, Tang End


SUBJECT 51L 195
CYL. SEG.
LOCATION 90°
DESCRIPTION PROPELLANT
PROFILE
DATE 3/22/86
MSFC
NASA
EP25

Photograph 6. Contact 195, SRB RH Segment, Propellant Profile

Photograph 7. Contact 195, SRB LH Segment, System Tunnel

SUBJECT 51-L L.H. SRB ET ATTACH FRAGMENT – TARGET #11

LOCATION EOD RANGE

DESCRIPTION PART WITH IDENTIFIER ON ET ATTACH RING FRAGMENT

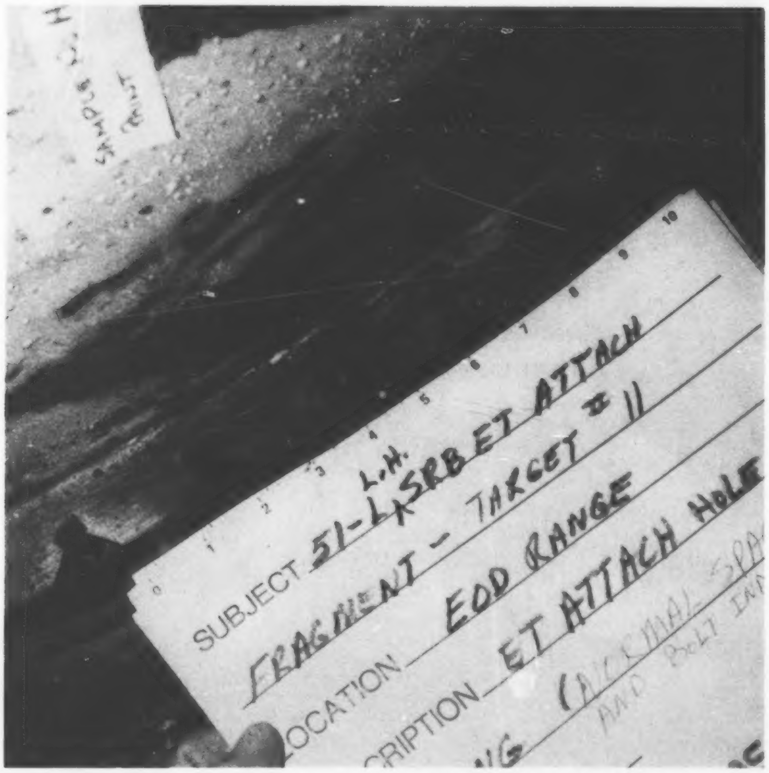
DATE 3/21/86

MSFC NASA EP25

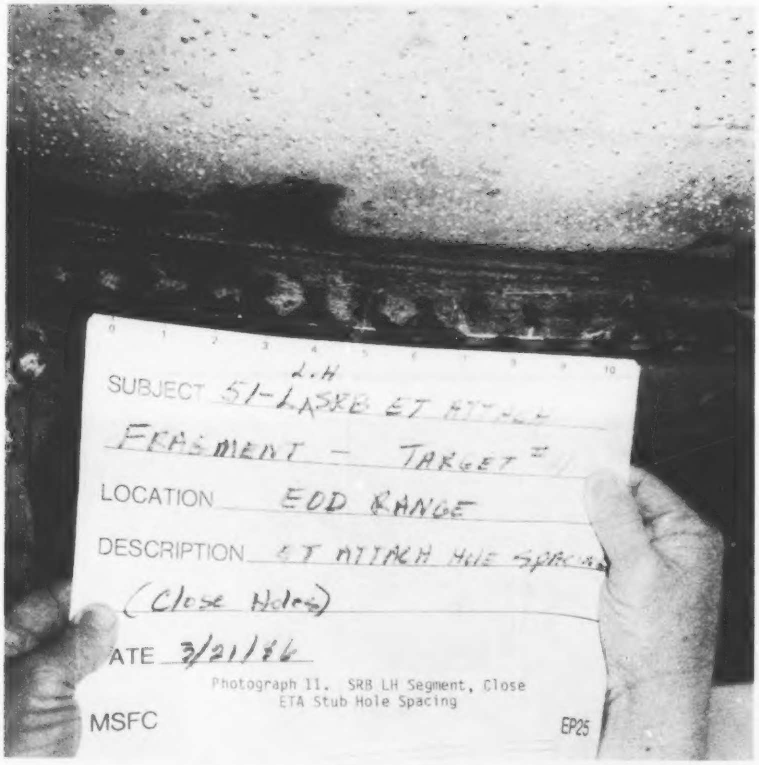
Photograph 8. Contact 11, SRB LH Segment, Component Serial/Part Number

SUBJECT 51-L LH SRB ET ATTACH
FRAGMENT TARGET #11
LOCATION EOD RANGE
DESCRIPTION
DATE 3/21/86

Photograph 9. Contact 11, SRB LH Segment, Propellant Burn Back Pattern


SAMPLE L. H
PAINT
SUBJECT 51-L L.H. SRB ET ATTACH
FRAGMENT - TARGET # 11
LOCATION EOD RANGE
DESCRIPTION ET ATTACH HOLE
(NORMAL SPA
AND BOLT IN

Photograph 10. Contact 11, SRB LH Segment, Wide ETA Stub Hole Spacing



SUBJECT 51-L L.H SRB ET ATTACH

FRAGMENT - TARGET #

LOCATION EOD RANGE

DESCRIPTION ET ATTACH HOLE SPACING

(Close Holes)

ATE 3/21/86

Photograph 11. SRB LH Segment, Close
ETA Stub Hole Spacing

MSFC EP25

Photograph 11. SRB LH Segment, Close ETA Stub Hole Spacing

SIL 26-1
TANG RJ
NASA

Photograph 12. Contact 26-1, SRB LH Segment, Serial/Part Number

Photograph 13. Contact 11, SRB LH Segment, Propellant Profile

TABLE III—MAJOR ASSETS USED BY THE TASK FORCE

Vessel ID	*Vessel Type*	*Task Assignment*	*Primary Capability*
Freedom Star	Surface Vessel	Search	Side Scan Sonar
Liberty Star	Surface Vessel	Search	Side Scan Sonar
G.W. Pierce	Surface Vessel	Search	Side Scan Sonar
P.L. III	Surface Vessel	Search	Side Scan Sonar
Seward Johnson w/Sealink II	Surface Vessel w/manned Submersible	Identification Recovery of small items	Underwater Video & Photo Manned Submersible
Edwin Link w/Sealink I	Surface Vessel w/manned Submersible	Identification Recovery of small items	Underwater Video & Photo Manned Sumersible
USS Sunbird w/NR-1	Surface Vessel w/manned nuclear powered Submersible	Identification	Long-Range Capability w/underwater Video and Photo
Independence w/Deep Drone	Surface Vessel w/Remote Operating Vehicle	Identification	Underwater Video
USS Preserver	Surface Vessel	Recovery	Dive Team to 190 Ft.
Stena Workhorse w/Gemini	Surface Vehicle w/Remote Operating Vehicle	Recovery	100-Ton Crane and Underwater Video
LCU	Surface Vessel	Recovery	Dive Team to 150 Ft.
Eliminator	Surface Vessel	Logistics	Logistics Support
Pelican Princess	Surface Vessel	Logistics	Logistics Support

B. *DEVELOPMENT OF PLAN*

In order to control and provide necessary information for salvage planning, a document was prepared for each recovered part identifying:

1) The specific hardware to be recovered
2) Its location
3) Priority
4) Sea vessels to be used
5) Timelines
6) Requirements for safe handling
7) Critical evidence protection and preservation
8) Transport to shore

Individual, self-contained plans including illustrations were generated and approved by Search, Recovery and Reconstruction Team members. Figures 13 through 33 give the rationale used to determine the hardware's location and orientation on the launch vehicle assembly. Photographs 14 through 18 show the recovery operations.

C. *SAFETY AND HAZARD CONSIDERATIONS*

The inadvertent separation of the SRB from the ET occurred prior to the engagement of the Pyro Initiator Circuit (PIC), which controls the deployment of the various pyro devices. All ordnance devices installed on the SRB's were assumed live during retrieval operations and handled with extreme care.

The following guidelines for lifting components from the ocean were established to prevent inadvertent ignition and damage to the recovered hardware.

1. Avoid use of steel hooks or cables which may come in contact with suspected burn through areas.
2. Stabilize part prior to loading on the ship.
3. Tie down parts immediately after loading onto ship.
4. Disarm ordnance.
5. Neutralize forward skirt batteries (for range safety system).
6. Examine hydrazine tanks located in aft skirt for leakage prior to personnel entering SRB area.

The following precautions were implemented for the propellant.

1. Keep wet.
2. Do not permit shear between hard surfaces.
3. Do not subject to direct heat/flame.

Contact 11, Left-Hand (LH) Attach Segment

- Section of Field Joint Clevis
    - Inhibitor in place
    - Outer leg of clevis broken off
- Left Hand
    - Ocean location in comparison to radar trajectory charts
    - Propellant profile
- Aft Segment
    - ETA Stub on piece
    - Distance from clevis to tang

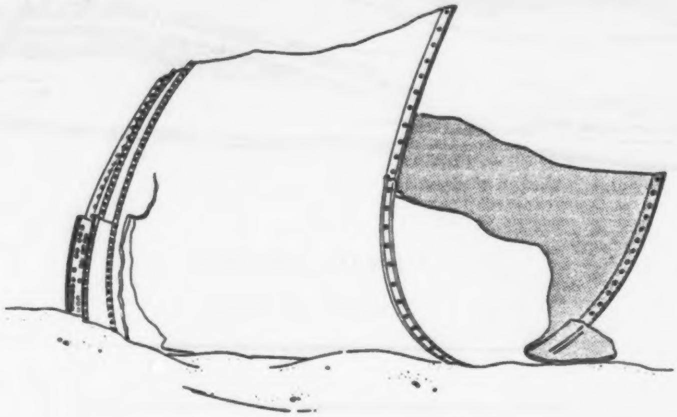


Figure 13. Contact 11

Contact 21-1, RH Aft Segment/Dome/Stiffener

- Aft Segment
    - Stiffener stubs on piece
    - Sitting on Aft Skirt
    - Kick Ring on piece
- Right Hand
    - Ocean location in comparison to radar trajectory chart
    - Proximity to hydraulic reservoir identified by serial number
    - Proximity to Aft Skirt with BSM configuration

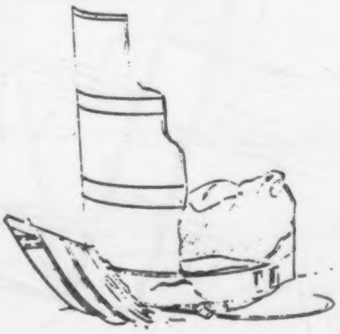


Figure 14. Contact 21-1

Contact 21-2, Case Tang Segment
- Cylinder of Aft Segment
    - Tang on piece
    - Insulation design
- Right Hand
    - Ocean location in comparison to radar trajectory charts
    - Proximity to known aft segment hardware

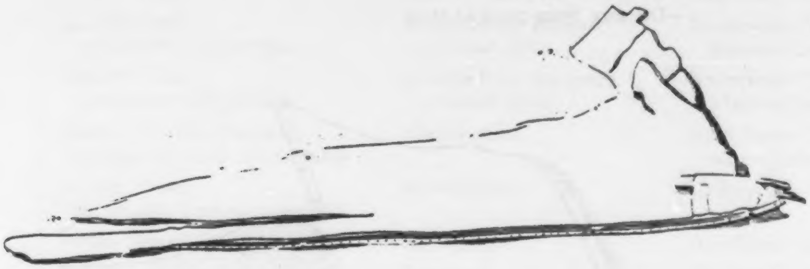


Figure 15. Contact 21-2

Contact 21-3, RH Aft Segment Fragment
- Aft Segment
    - Stiffener ring stub on piece
    - Urethane foam on piece
    - Factory joint
- Right Hand
    - Ocean location in comparison to radar trajectory charts
    - Sooted appearance
- Located schematically at 90 degrees
    - Systems tunnel defines 90-degree location
    - Stiffener ring stubs locate longitude

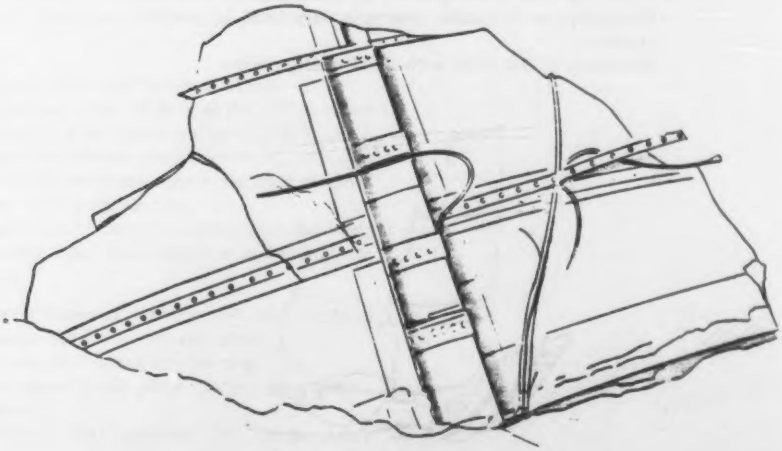


Figure 16. Contact 21-3

Contact 21-4, Aft Segment – Stiffener

- Section of field joint clevis
    - Clevis legs remain
    - Stiffener ring stub on piece
- Right Hand
    - Ocean location in comparison to radar trajectory charts

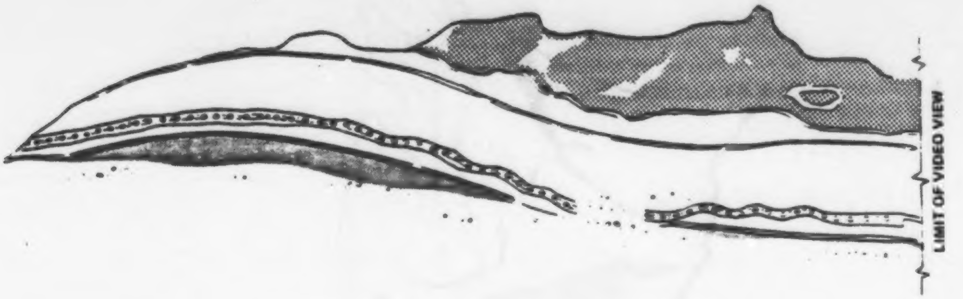


Figure 17. Contact 21-4

Contact 21-5, Aft Segment – Stiffener Ring Segment

- Aft Segment – Forward Stiffener
    - Two stiffener ring stubs on piece
    - Foam traces on Aft Stub/no trace on Forward Stub
    - Distance from clevis to tang
- Right Hand
    - Ocean location in comparison to radar
    - Sooted appearance

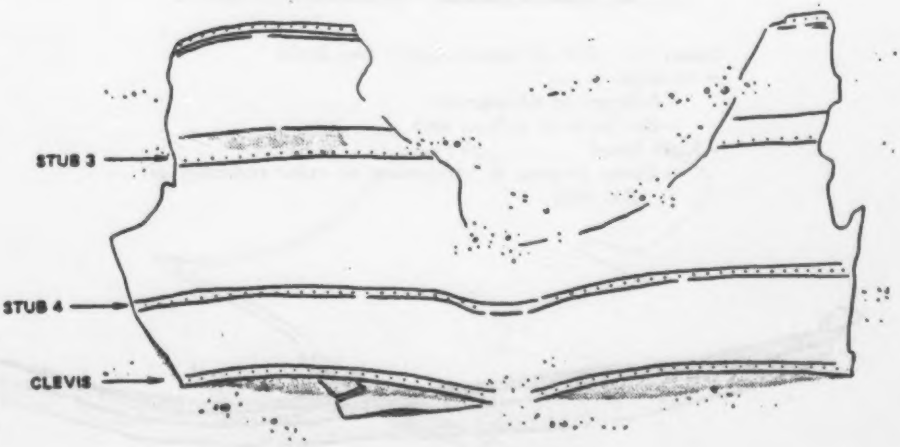


Figure 18. Contact 21-5

Contact 21-6, Aft Segment—Stiffener Segment
- Aft Segment
  - Stiffener stub on piece
  - Distance from tang to stiffener stub
- Right Hand
  - Ocean location in comparison to radar trajectory chart

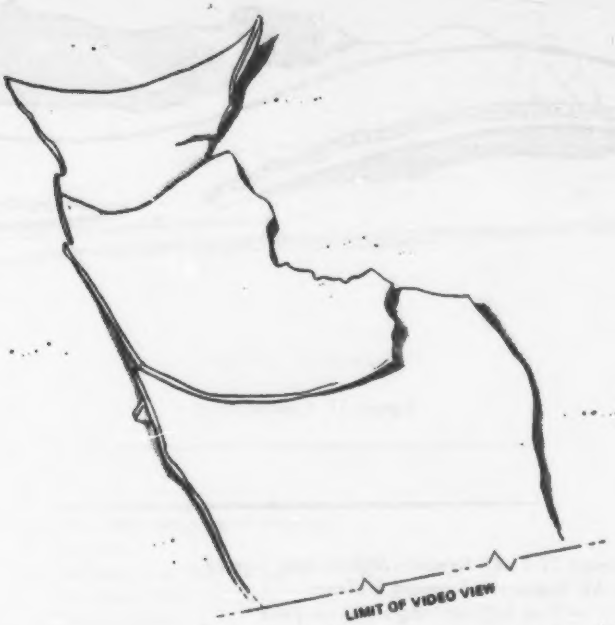


Figure 19. Contact 21-6

Contact 21-7, SRB Aft Segment Stiffener Ring Section
- Aft Segment
  - Stiffener on Aft segment
  - Bolt holes on stiffener stub
- Right Hand
  - Ocean location in comparison to radar trajectory of RH SRB

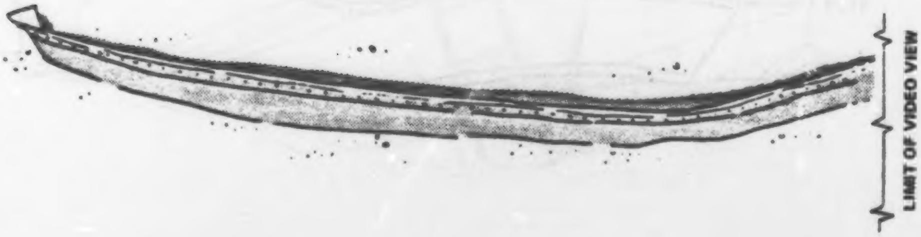


Figure 20. Contact 21-7

Contact 21-8, SRB Fragment

- Right Hand
  - Ocean location in comparison to radar trajectory charts
  - Sooted appearance

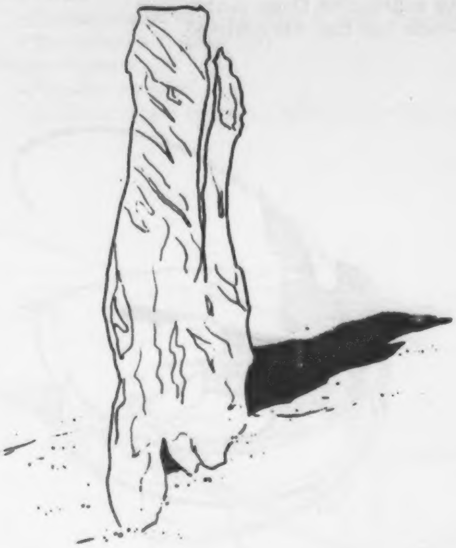


Figure 21. Contact 21-8

Contact 21-9, Aft Segment—Stiffener

- Aft Segment—Aft Stiffener
  - Stiffener ring stub on piece
  - Section of factory joint clevis
  - Torn insulation at clevis joint
- Right Hand
  - Ocean location in comparison to radar trajectory chart

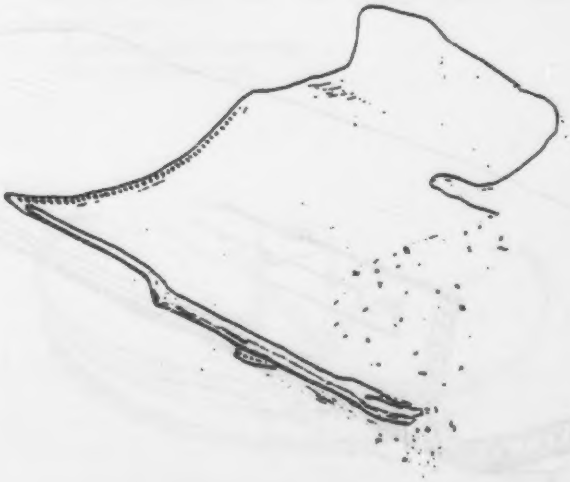


Figure 22. Contact 21-9

Contact 24, Left Hand Aft Segment

- Left Hand
    - Known LH due to positive identification of RH Aft Dome
- Aft Dome
    - Presence of kick ring
    - Aft stiffener/Aft Dome factory joint
    - Nozzle bolt that was retrieved

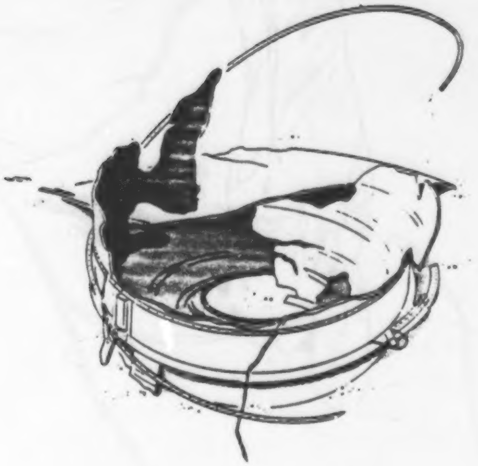


Figure 23. Contact 24

Contact 26-1, LH Aft Center Segment, Forward Cylinder

Drawing and part number stenciled on hardware positively identified this piece.

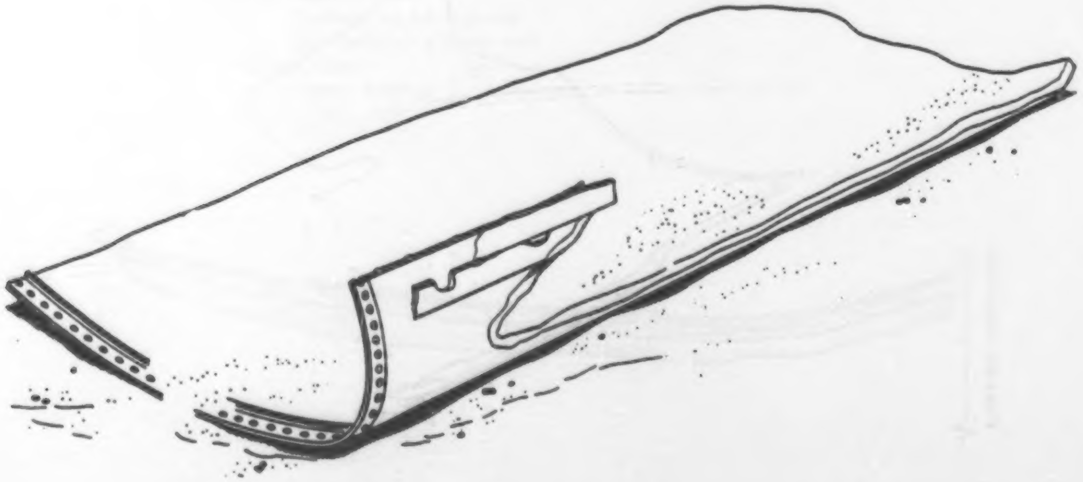


Figure 24. Contact 26-1

Contact 26-2, LH Aft Center Segment, Forward Cylinder
- Section of Field Joint Clevis
  - Inhibitor in place
  - Outer leg of clevis broken off
  - Insulation design
- Left Hand
  - Ocean location in comparison to radar trajectory charts
  - Proximity to Contact 26-1
- Center Segment
  - Propellant profile
  - Inhibitor height consistant with Center Segment

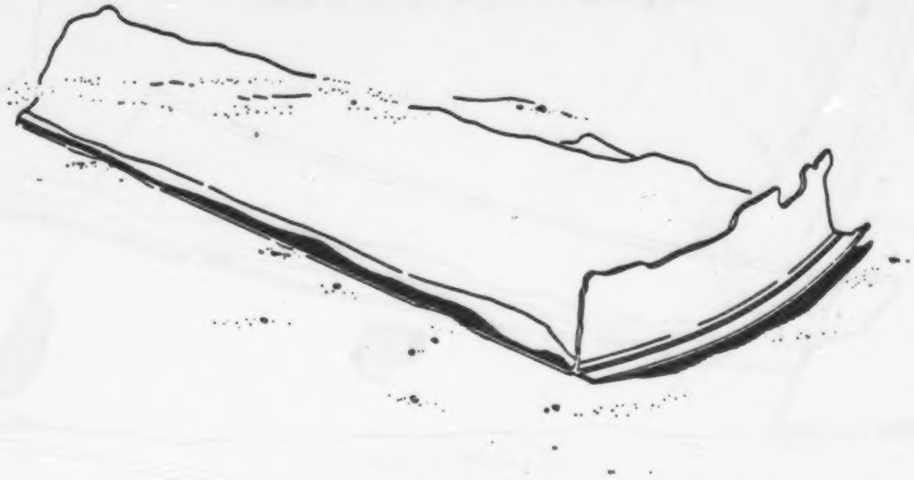


Figure 25. Contact 26-2

Contact 41, Forward Dome with Igniter
- Right Hand
  - Ocean location in comparison to radar trajectory charts
- Forward Dome
  - Contains igniter assembly
  - Correct dome height

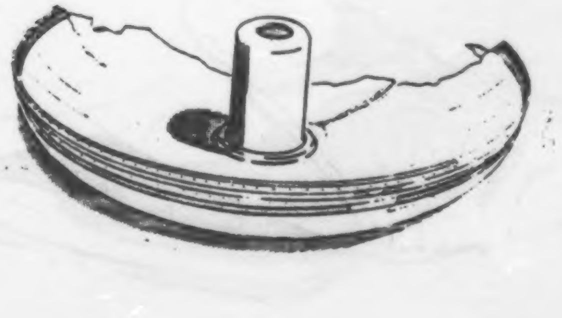


Figure 26. Contact 41

Contact 195, Section of Factory Joint Tang
- SECTION OF FIELD JOINT CLEVIS
    - clevis legs remain
    - insulation design
- RIGHT HAND
    - sooted appearance
    - propellant quantity from burnback charts
    - ocean location directly on RH track
- FORWARD CYLINDER OF AFT CENTER SEGMENT
    - cylinder section piece
    - propellant location from burnback charts
- LOCATED SCHEMATICALLY AT 90 TO 250 DEGREES
    - systems tunnel defines 90-degree edge
    - two index slots on tang (at 118 and 240 degrees)

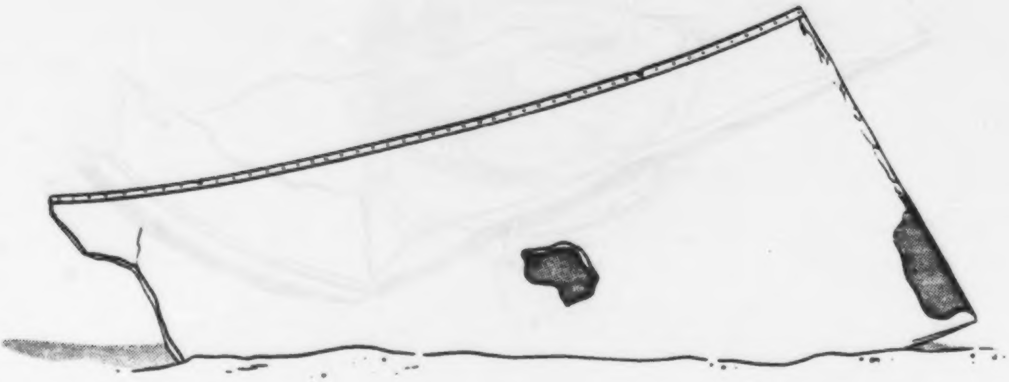


Figure 27. Contact 195

Contact 214, Section of Forward Center Segment
- Propellant burnback charts
- Factory tang joint

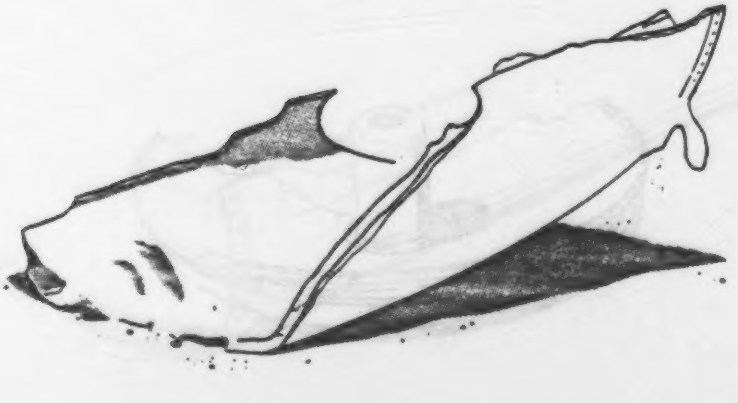


Figure 28. Contact 214

Contact 292, Section of Field Joint Clevis

- RIGHT HAND
  - sooted appearance
  - propellant quantity from burnback charts
  - ocean location south of RH track
- AFT SEGMENT
  - ET attach stubs on piece
  - clevis legs remain
  - insulation design
- LOCATED SCHEMATICALLY AT 108 TO 140 DEGREES
  - hole pattern in attach stubs in 90-180 degrees pattern
  - no evidence of LSC cutting
  - no ablative compound over bolt holes
  - tape marks around one pin hole indicates assembly alignment for the 118 degrees index

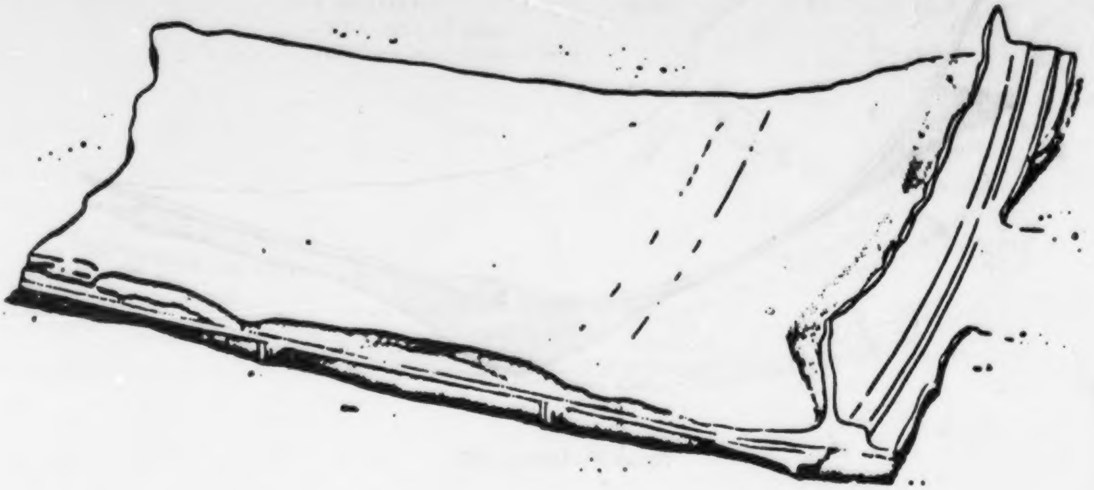


Figure 29. Contact 292

Contact 301, Section of Factory Joint Clevis

- SECTION OF FIELD JOINT CLEVIS
  - joint intact
  - insulation design
  - clevis legs remain
- RIGHT HAND
  - sooted appearance
  - propellant quantity from burnback charts
  - ocean location close to RH track
- AFT CYLINDER OF FORWARD SEGMENT
  - cylinder section piece
  - propellant location by joint from burnback charts
- LOCATED SCHEMATICALLY AT 0 TO 90 DEGREES
  - leak check port defines 0 degree
  - systems tunnel defines 90 degrees edge
- CONFIRMATION
  - part and serial number steel stamped on part joint

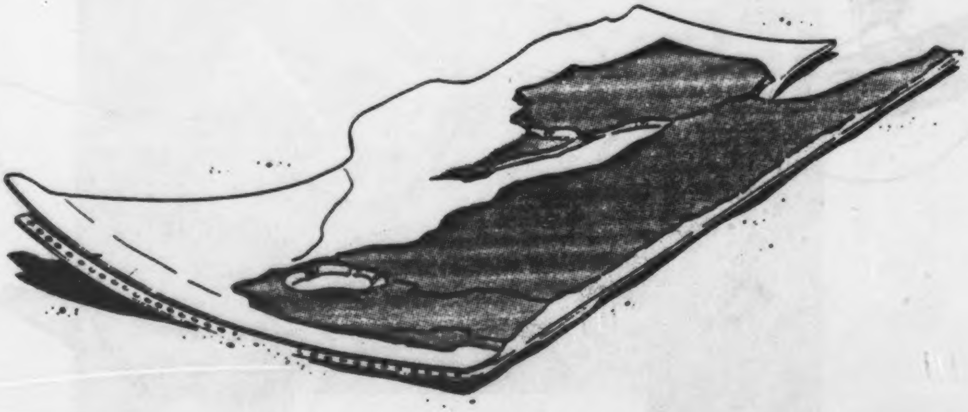


Figure 30. Contact 301

Contact 325, SRB Case Cylinder – Clevis Joint

- Section of factory joint clevis
  - Outer leg of clevis broken off
  - Insulation design
  - No mold controlled insulation joint

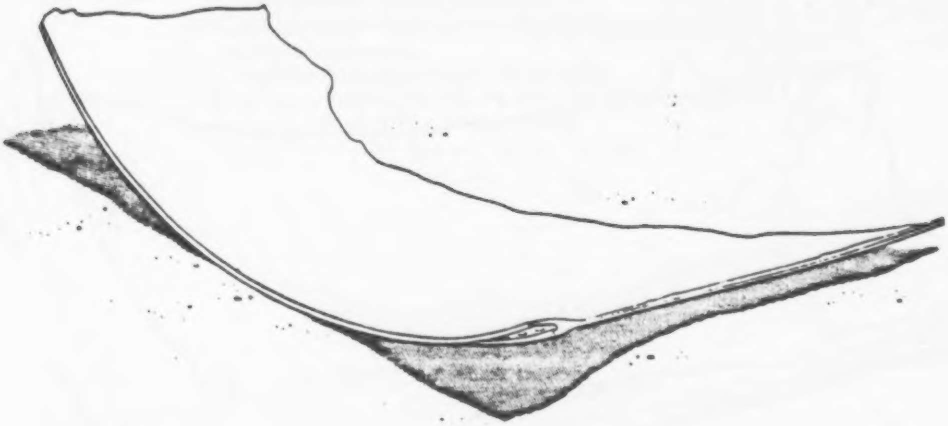


Figure 31. Contact 325

Contact 502, RH SRB Cylinder Segment, Field Joint Tang

- Section of Aft Cylinder
  - Factory joint w/leak check port
  - Mold controlled insulation
  - Propellant Flap
  - Alignment pin slot
  - Propellant burnback profile
- Right Hand
  - Ocean location in comparison to radar trajectory charts
  - Sooted appearance
  - Propellant quantity from burnback charts

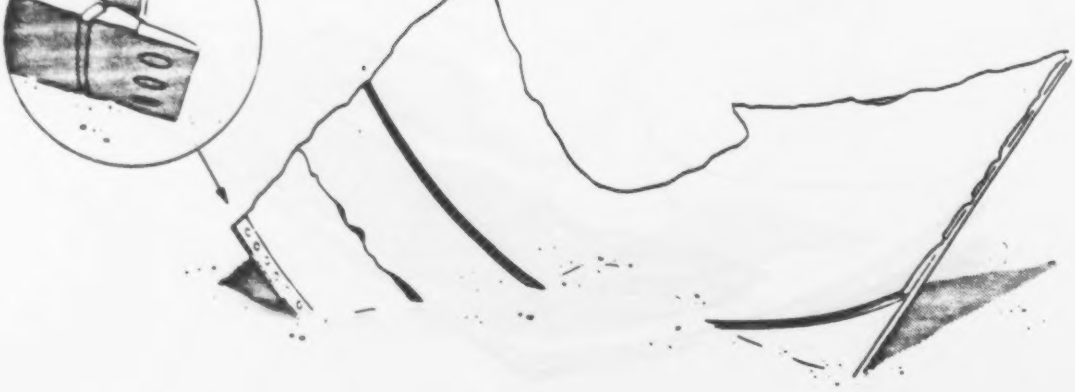


Figure 32. Contact 502

Contact 579, Section of Field Joint Clevis

- SECTION OF FIELD JOINT CLEVIS
  - inhibitor in place
  - outer leg of clevis broken off
  - insulation design
- RIGHT HAND
  - ocean location in comparison to radar trajectory charts
  - sooted appearance
  - propellant quantity from burnback charts
- AFT SEGMENT
  - ETA stubs on piece
  - distance from clevis to tang

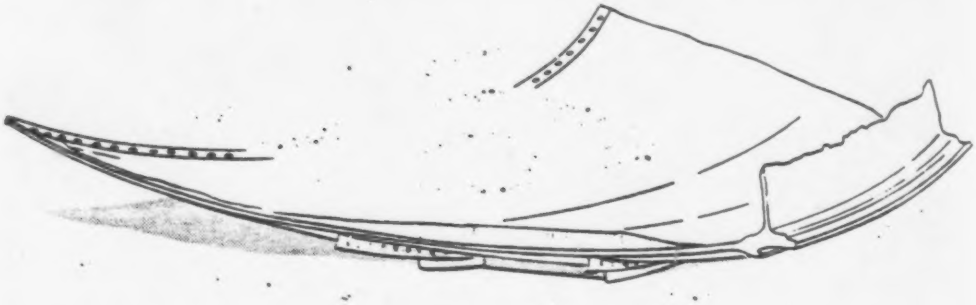
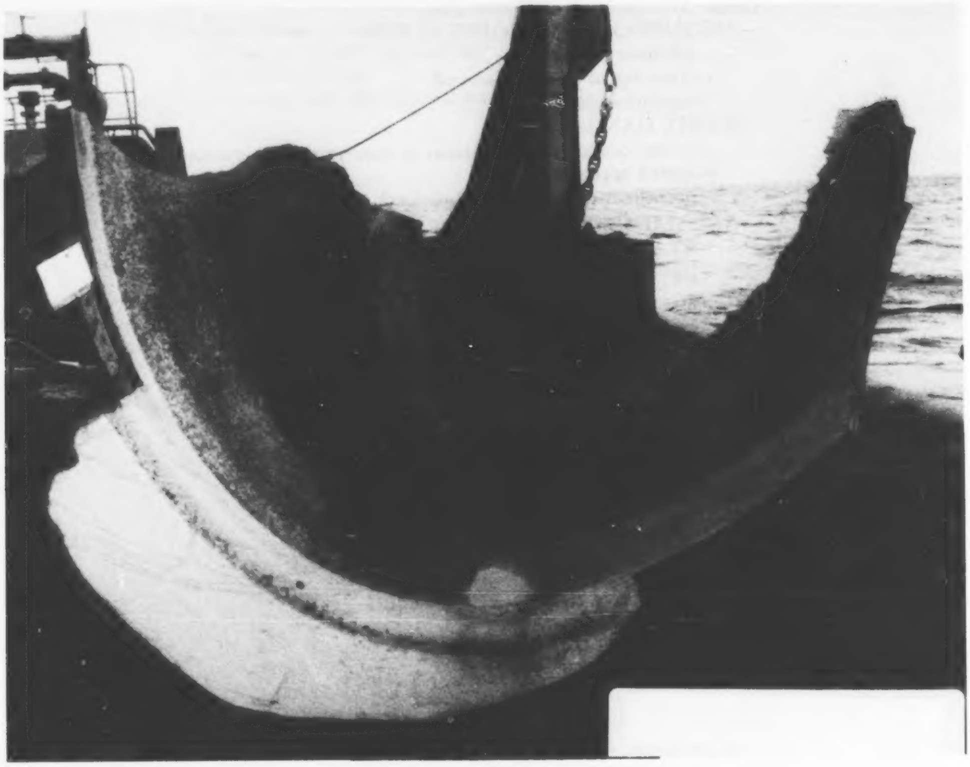


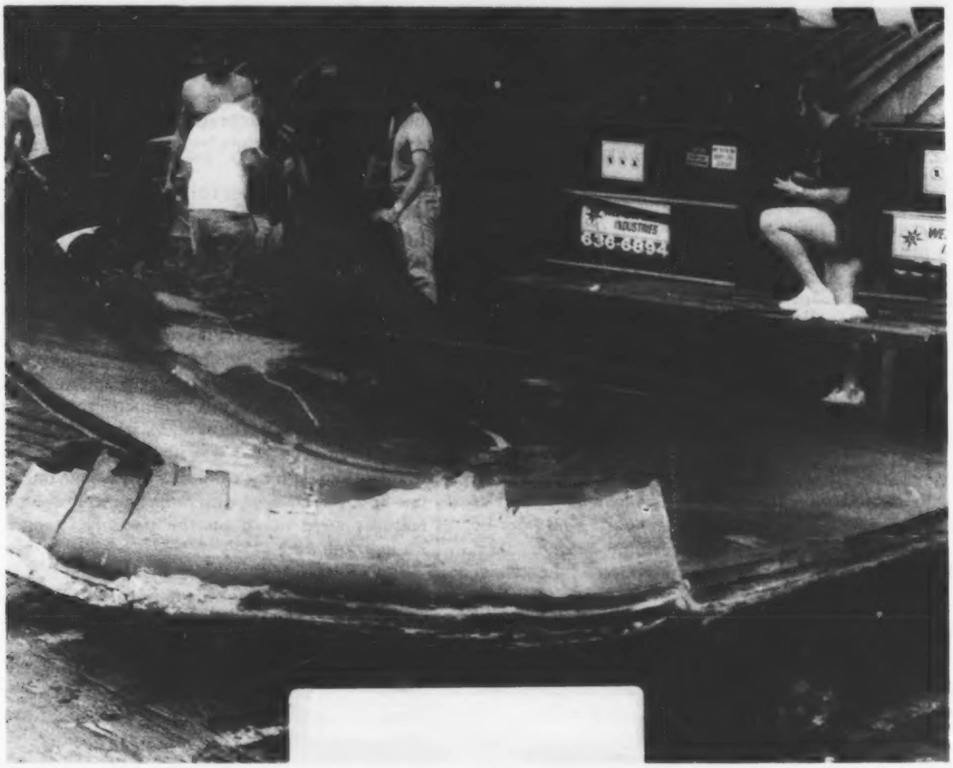
Figure 33. Contact 579

Photograph 14. Contact 11, SRB LH Segment, Sea Recovery



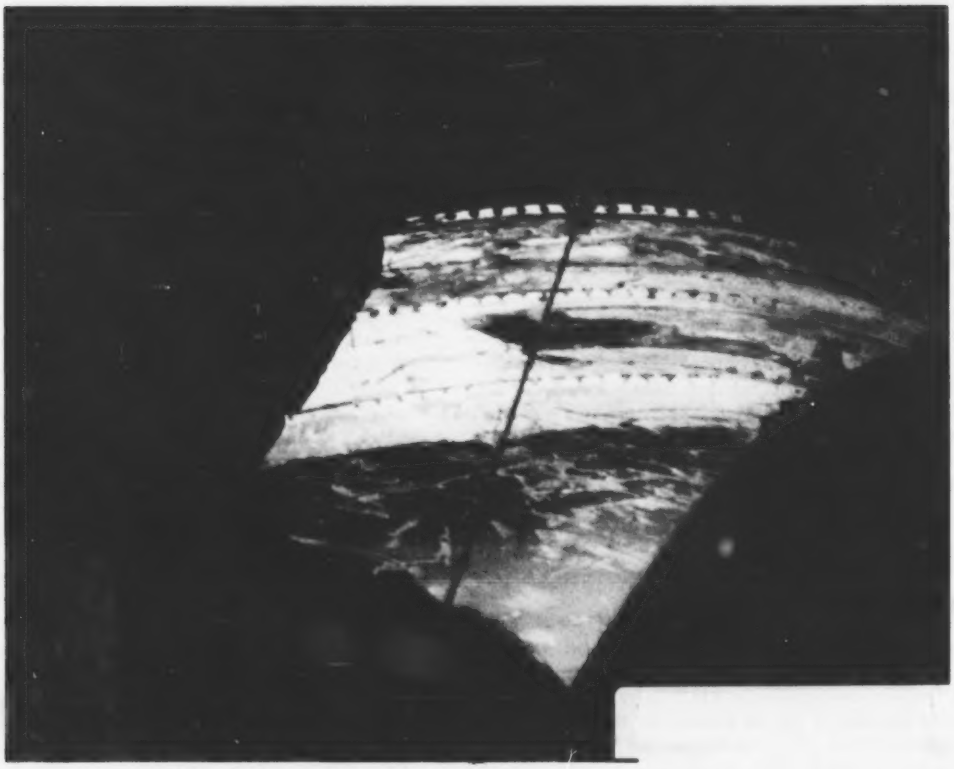
Photograph 15. Contact 11, SRB LH Segment, Sea Recovery

Photograph 16. Contact 301, SRB RH Segment, Sea Recovery



INDUSTRIES
636-6894

Photograph 17. Contact 195, SRB RH Segment, Sea Recovery



Photograph 18. Contact 292, SRB RH Segment, Sea Recovery

4. Do not shock/drop.

5. Use sand bags or wood pallets to secure or brace while handling the segments of steel and propellant.

6. Do not place pieces of propellant in contact with each other except during and just prior to actual disposal operation.

7. Loose propellant should not be placed in contact with or on any case segment with propellant attached.

8. Store loose propellant in an approved container.

9. Propellant sensitivity is a function of thickness and porosity following sustained exposure to water.

10. Do not handle AP crystals. Insure that crystal areas are wetted down prior to movement of any propellant.

V. *DESCRIPTION OF RECOVERED HARDWARE*

A summary listing of all SRM hardware, including information relative to identification and location, is shown on Table IV. Due to the lack of identifying features, some parts could not be identified to the extent necessary to determine exact location on the SRB. A description of each part is provided on the following pages. Table IV summarizes the recovery hardware.

CONTACT #11—This was the first SRB part recovered. The part was identified as a large fragment of the ET attach segment, aft segment, LH SRB. Identification was made by propellant profile analysis, hole patterns on the attach stubs, and electrical connector part numbers. The part contained both attach stubs, a tang and clevis, and a fragment of the forward stiffener segment which was attached to the tang. Approximately 80% of the interior surface was covered with propellant. (Reference Figures 34 and 35, and Photograph 19.)

CONTACT #21-1—This part was identified as fragments of the aft dome, aft stiffener segment, and kick ring, RH SRB. This part was identified by the part number and serial number found on the exterior surface of the part. This was a very large part and was significant in providing a base for reconstruction of the RH SRB aft segment. There was no propellant on this piece. (Reference Figure 36 and Photographs 20 and 21.)

CONTACT #21-2—This part was identified as a RH forward stiffener segment and was identified by dimensional analysis which proved that the part matched with Contact 21-3. Contact 21-3 was positively identified as RH SRB. A factory clevis with a missing outer leg, the inactive and forward stiffener stubs, and a factory joint tang were the major design features contained on this part. There was no propellant on this part. (Reference Figure 37 and Photograph 22).

CONTACT #21-3—This part has been identified as a fragment of the forward stiffener segment, aft segment, RH SRB. The part was identified by part number (1U50715-02) and serial number (0000002R2) found on exterior surface. Major features of this part are a clevis with the outer leg broken off and a portion of the systems tunnel. There is no propellant on the part. (Reference Figure 38 and Photograph 23.)

CONTACT #21-4—This part has been identified as a fragment of the aft stiffener segment, aft segment, RH SRB. It was identified by the part number and serial number found on the part. Major features of the part are a field joint clevis and a stiffener ring stub. There is no propellant on the part. (Reference Figure 39 and Photograph 24.)

CONTACT #21-5—This part is a fragment of RH aft segment, forward stiffener segment, containing the inactive stiffener stub and the active forward stiffener ring stub. The part mates with Contact 21-3 which was identified as RH SRB by a serial number. It was located laterally on the aft segment by the leak test port at 0° on the clevis. There is no propellant on this piece. (Reference Figure 40 and Photograph 25.)

CONTACT #21-9—This part was identified as a fragment of the RH stiffener segment by part number (1U50715) and serial number (0000001R2) found on the exterior surface. The outer surface is heavily sooted except where foam residue is present. A factory clevis and factory tang are present on the piece. The piece contained no propellant. There is no evidence of heat damage on either the clevis or tang. (Reference Figure 41 and Photograph 26.)

CONTACT #26-1—This part has been identified as the forward cylinder of the aft center segment, LH SRB. It was identified by a serial number found on the part. Major features of the part are a factory joint tang and systems tunnel floor plate fragments. The interior surface is covered with propellant. There are no apparent indications of leakage or other abnormal appearance. (Reference Figure 42 and Photograph 27.)

CONTACT #26-2—This part was identified as a fragment of the forward cylinder, aft center segment, LH SRB. Identification was made as a result of dimensional analysis which proved that the part physically mates with Contact 26-1 at the fracture surface. Contact 26-1 was identified by serial number and part number found on the exterior surface. The interior surface of Contact 26-2 was covered with propellant. No anomalous performance features were noted on the part. (Reference Figure 43 and Photograph 28.)

CONTACT #131—this part was identified as RH SRB aft cylinder of the aft center segment. Part number (1U50717-02) and serial number (0000060R1) were found on the exterior surface of the part. The location of the burned out area found on the part was consistent with photographic data (294 to 316). Circumferential location was determined by discovery of the 0° alignment slot on the tang. There is propellant over approximately 90% of the surface. This part was considered a very significant finding since it is a part of the suspected burned through joint. (Reference Figures 44 through 52, and Photographs 29 through 32.)

CONTACT #195—This part has been identified to be a section from the forward case cylinder, forward center segment, LH. The conclusion was based upon the geometry of the part which included propellant profile, plant joint tang, and field joint clevis. The tang thickness measurements were taken and favorably agreed with the manufacturing records. No anomalous performance indications were noted. (Reference Figure 53 and Photograph 33.)

CONTACT #196—This part was identified as LH forward dome by part number (1U51473-01) and serial number (0000035) found on the part. The exterior surface is heavily sooted. No propellant was present. Insulation is present over 100% of the interior surface. (Reference Figure 54 and Photograph 34.)

CONTACT #214—This part is a fragment of case cylinder with a factory tang and field clevis. No further identification could be made due to lack of additional identifying features. The outside surface is lightly sooted. There is propellant over approximately 60% of the interior surface. (Reference Figure 55 and Photograph 35.)

CONTACT #292—This part was identified as a fragment of the RH ET attach segment, aft segment. Identification was based upon comparison of the propellant profile of the part with the propellant profile on Contact #11 which is a known LH SRB attach segment part. This part was of particular interest since it contains a section from the suspect failure field joint. However, other than having a heavily-sooted appearance, no apparent indication of anomalous performance was noted. (Reference Figures 56 and 57, and Photograph 36.)

CONTACT #301—This part was identified to be a large fragment from the aft case cylinder of the RH forward segment. Identification was made from part number and serial number found on the exterior surface. The part contains a plant joint (clevis) and field joint (tang). No anomalous performance indications were found on the hardware. (Reference Figure 58 and Photograph 37.)

CONTACT #312—FRUSTUM SHEAR BEAM—Two fragmented pieces of frustum shear beam were recovered. These were identified by their shape and components that were attached.

TABLE IV 51-L SRM RECOVERED HARDWARE

Target	Title	Joint	ID Method
11	L. H. Aft Seg, ET Attach	Clevis Field & Tang Factory	Propellant Profile & Connector P/N
21-1	R. H. Aft Seg, Aft Stiffener/Aft Dome	Clevis Factory & Tang Factory	Part No. & Serial No.
21-2	R. H. Aft Seg, Fwd Stiffener	Clevis Factory & Tang Factory	Mates with 21-3
21-3	R. H. Aft Seg, Fwd & Aft Stiffener	Clevis Factory	Part No. & Serial No.
21-4	R. H. Aft Seg, Aft Stiffener	Clevis Factory	Part No. & Serial No.
21-5	R. H. Aft Seg-Fwd Stiff	Clevis Factory & Tang Factory	Mates with 21-3
21-9	R. H. Aft Seg, Aft Stiffener	Clevis Factory & Tang Factory	Part No. & Serial No.
26-1	L. H. Aft Ctr, Fwd Case Seg	Tang Factory	Part No. & Serial No.
26-2	L. H. Aft Ctr, Fwd Case Seg	Clevis Field	Mates with 26-1
131	R. H. Aft Ctr Seg, Aft Cylinder	Tang Field	Part No. & Serial No.
195	L. H. Fwd Ctr Seg, Fwd Cylinder	Clevis Field & Tang Factory	Tang Thickness Measurements
196	L. H. Fwd. Seg Dome	Tang Factory/Field	Part No. & Serial No.
214	Ctr Seg, Fwd Cyl (Light Wt.)	Clevis Field & Tang Factory	Unidentifiable
292	R. H. Aft Seg-ET Attach	Clevis Field	Propellant Profile - Diff to L. H.

TABLE IV 51-L SRM RECOVERED HARDWARE–Continued

Target	Title	Joint	ID Method
301	R. H. Fwd Seg, Aft Cyl.	Clevis Factory & Tang Field	Part No. & Serial No.
325	R. H. Fwd Seg Aft Cyl	Clevis Factory	Insulation Erosion Pattern
433	Aft Ctr Seg, Fwd Cylinder	Clevis Field	Inhibitor Height
433-1	R. H. Aft Ctr Seg, Aft Cylinder	None	Mates with 433-2
433-2	R. H. Aft Ctr Seg, Aft Cylinder	Tang Field & Clevis Factory	Mates with 131
468	Fwd Seg, Aft Cyl	Clevis Factory & Tang Field	Propellant Burn Back Pattern
487	Forward Skirt Clevis	Clevis	Holes Spaced at 1°/ Crotch Seal
502	R. H. Fwd Ctr Seg, Aft Cyl	Tang Field	Part No. & Serial No.
524	Case Cylinder	None	Unidentifiable
538	R. H. Fwd Skirt	N/A	Paint Pattern
579	R. H. Aft Seg, ET Attach	Clevis Field & Tang Factory	Part No. & Serial No.
605	Fwd Seg, Fwd Cylinder	Clevis Factory	Insulation Buildup at Clevis
615-3	R. H. Aft Seg, Aft Stiffener	None	Mates with 21-1 & 21-4

TABLE IV. 51-L SRM RECOVERED/HARDWARE—CONTINUED

Target	Title	Joint	ID Method
615-4	Small Piece-Case	None	Unidentifiable
615-1A	R. H. Fwd Ctr Seg, Fwd Cyl	Tang Factory	Mates with 615-2
615-1B	R. H. Fwd Ctr Seg, Fwd Cyl	Clevis Field	Mates with 615-1A
615-2	R. H. Fwd Ctr Seg, Fwd Cyl	Clevis Field	Part No. & Serial No.
631	Ctr Seg, Fwd Cyl	Clevis Field & Tang Factory	Unable to Identify L.H. or R.H.
635	L. H. Fwd Seg Fwd CYlinder	Clevis Factory	Tang Thickness Measurement
699	R. H. Fwd Ctr Seg, Aft Cylinder	Clevis Factory & Tang Field	Part No. & Serial No.
711	Fwd Dome	Fsd Skirt Clevis	Desgin Features
712	R. H. Aft Segment, ET Attach	Tang Field	Rework on Attach Ring
5038	Fwd Seg, Aft Cyl	Clevis Factory	Propellant Burn Back Pattern
5039	Case Cylinder	Tang - Unknown Field/Factory	Unidentifiable
5124	L. H. ET/SRB Diagonal Strut	None	Serial Number
5126-1	Fwd Seg, Aft Cyl	Clevis Factory	Propellant BUrn Back Pattern
5126-2	Fwd Seg, Aft Cyl	None	Wall Thickness
5128	Fwd Seg, Case Cyl	Tank - Unknown Field/Factory	Wall Thickness

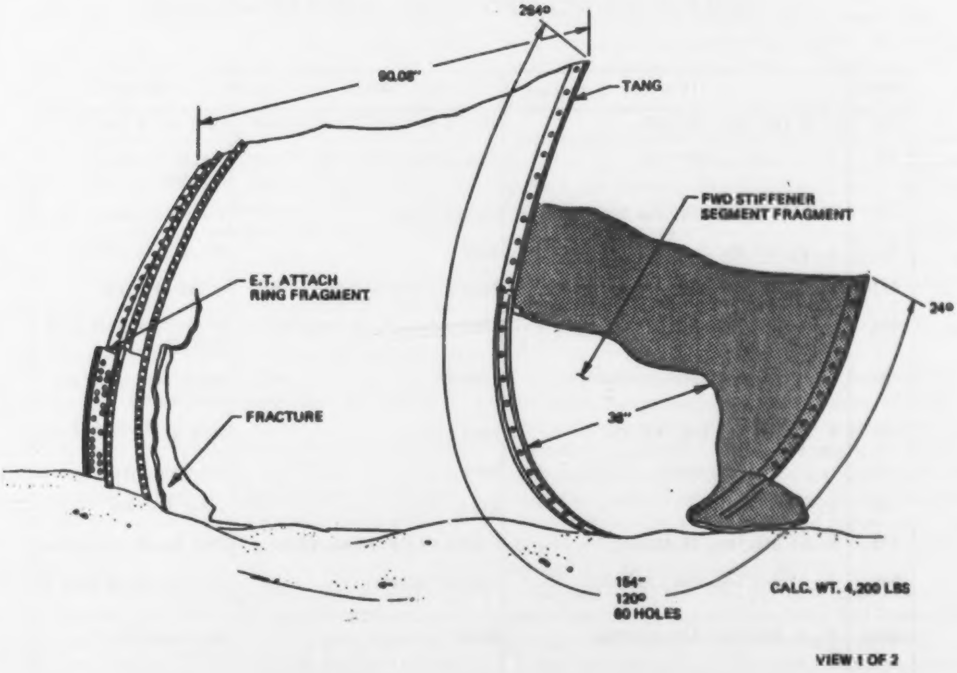

284°
90.08"
TANG
FWD STIFFENER
SEGMENT FRAGMENT
E.T. ATTACH
RING FRAGMENT
24°
FRACTURE
38"
184"
120°
60 HOLES
CALC. WT. 4,200 LBS
VIEW 1 OF 2

Figure 34. Contact 11, LH ET Attach Segment

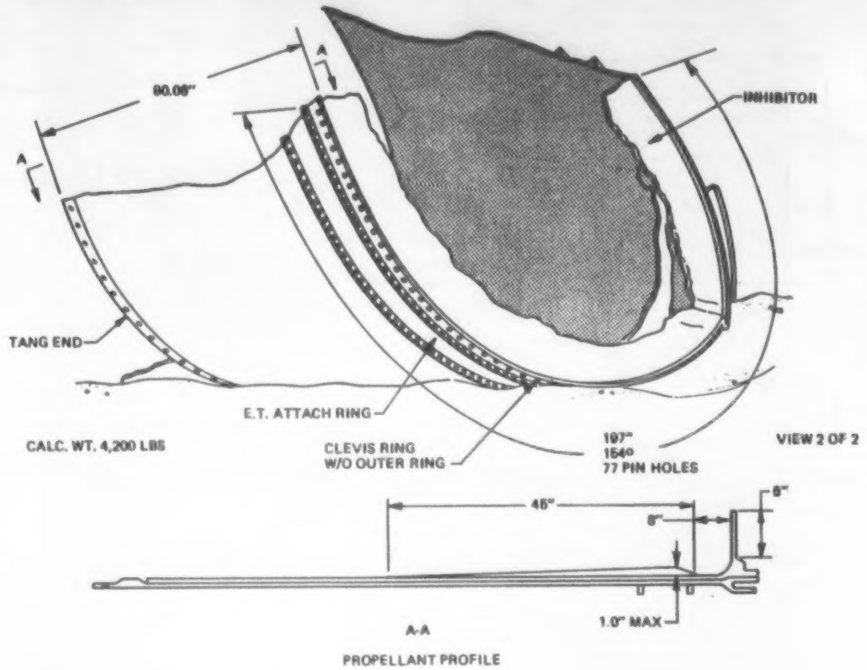

90.06"
A
A
INHIBITOR
TANG END
E.T. ATTACH RING
CALC. WT. 4,200 LBS
CLEVIS RING
W/O OUTER RING
197"
154°
77 PIN HOLES
VIEW 2 OF 2
45"
8"
5"
1.0" MAX
A-A
PROPELLANT PROFILE

Figure 35. Contact 11,. LH ET Attach Segment

Photograph 19. Contact 11, SRB LH Segment, Aft ET Attach Segment

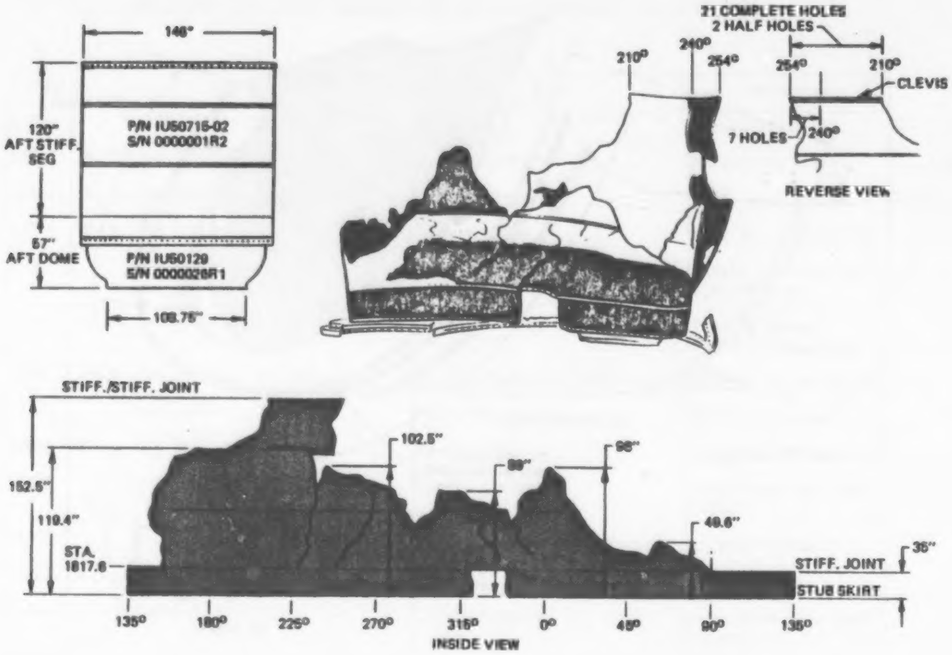
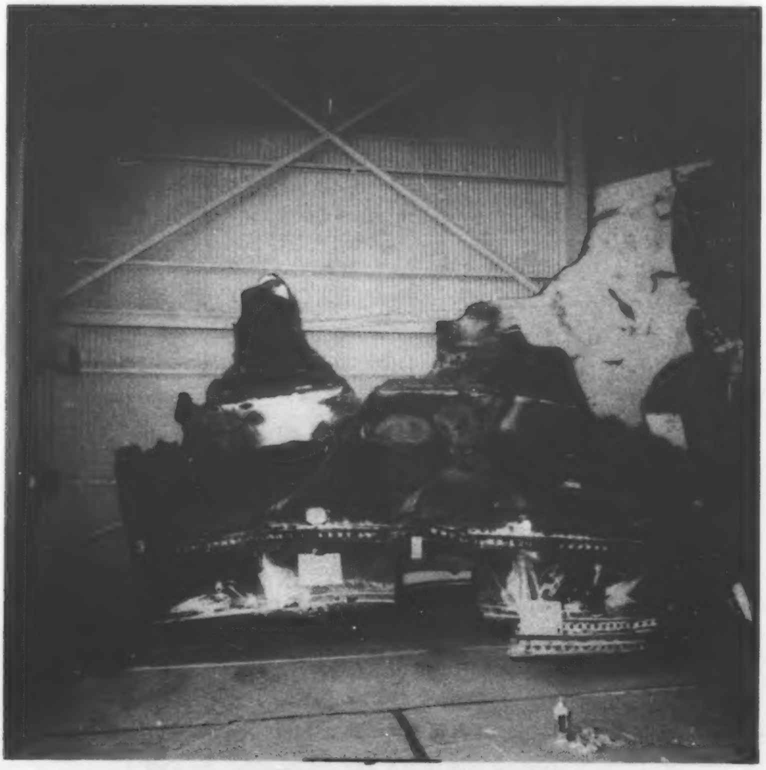
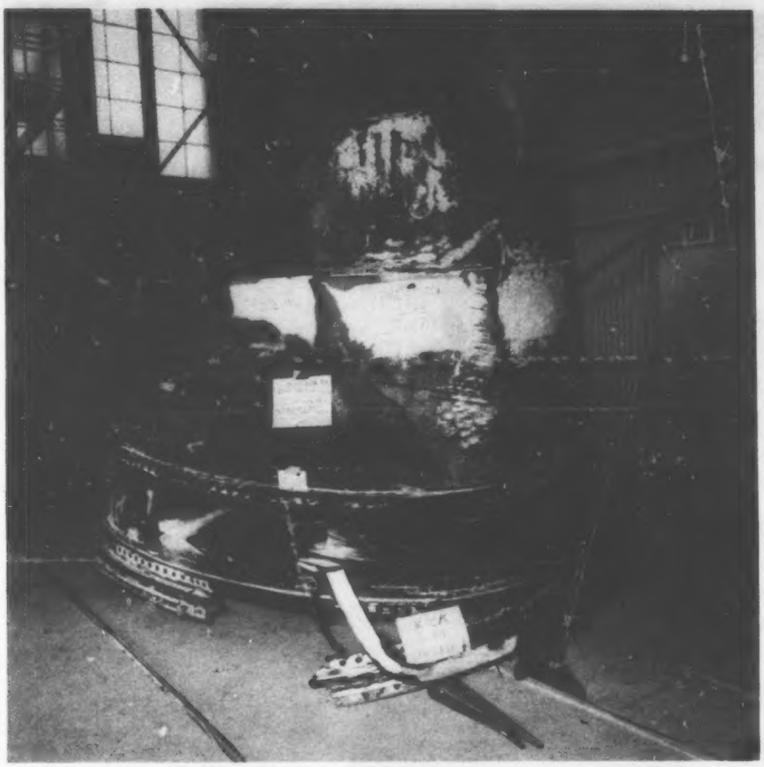

146"
120"
AFT STIFF.
SEG
P/N 1U50716-02
S/N 0000001R2
57"
AFT DOME
P/N 1U50129
S/N 0000026R1
108.75"
21 COMPLETE HOLES
2 HALF HOLES
210°
240°
254°
254°
210°
CLEVIS
7 HOLES
240°
REVERSE VIEW
STIFF./STIFF. JOINT
152.5"
119.4"
STA.
1817.6
102.5"
89"
96"
49.6"
36"
STIFF. JOINT
STUB SKIRT
135°
180°
225°
270°
315°
0°
45°
90°
135°
INSIDE VIEW

Figure 36. Contact 21-1, RH Aft Case Segment, Aft Stiff/Aft Dome Joint



Photograph 20. Contact 21-1, RH Aft Segment, Aft Stiff/Aft Dome Joint, View #1



Photograph 21. Contact 21-1, RH Aft Segment, Aft Stiff/Aft Dome Joint, View #2

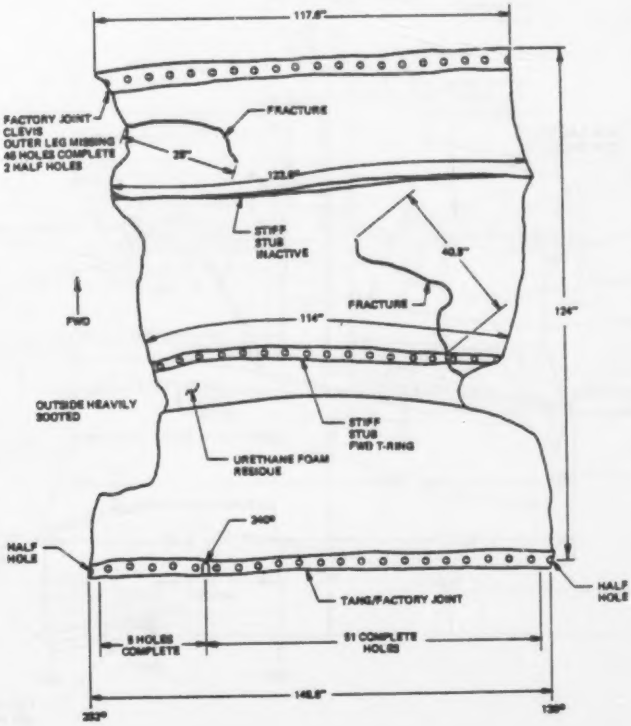
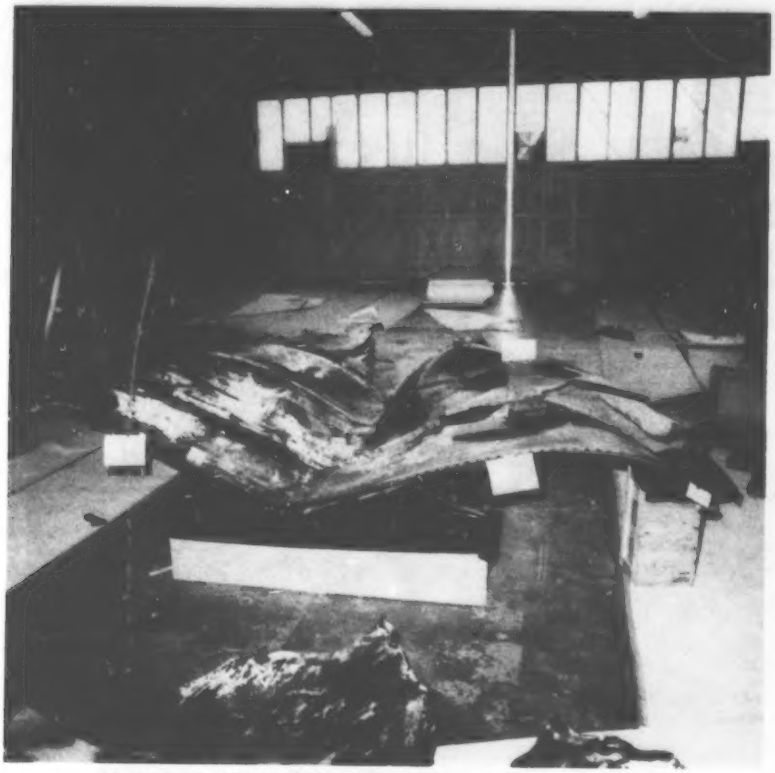

117.8"
FACTORY JOINT
CLEVIS
OUTER LEG MISSING
46 HOLES COMPLETE
2 HALF HOLES
FRACTURE
28"
123.8"
STIFF
STUB
INACTIVE
40.8"
FWD
FRACTURE
114"
124"
OUTSIDE HEAVILY
SOOTED
STIFF
STUB
FWD T-RING
URETHANE FOAM
RESIDUE
240°
HALF
HOLE
HALF
HOLE
TANG/FACTORY JOINT
5 HOLES
COMPLETE
51 COMPLETE
HOLES
146.8"
252°
135°

Figure 37. Contact 21-2, RH Aft Segment, Forward Stiffener



Photograph 22. Contact 21-2, RH Aft Segment, Forward Stiffener

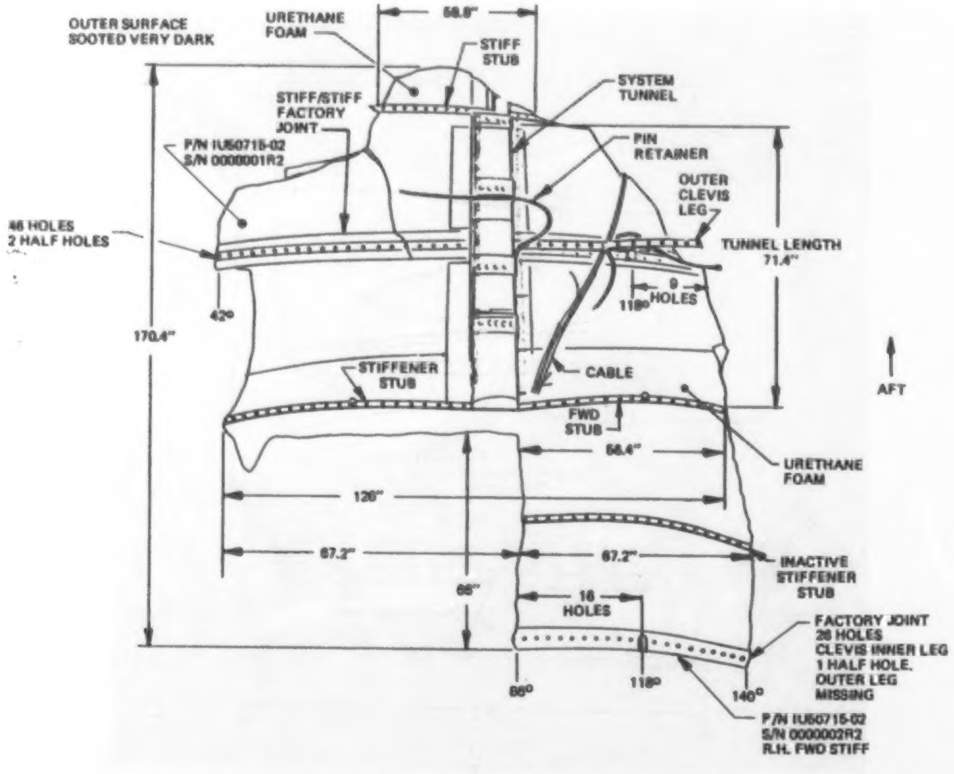
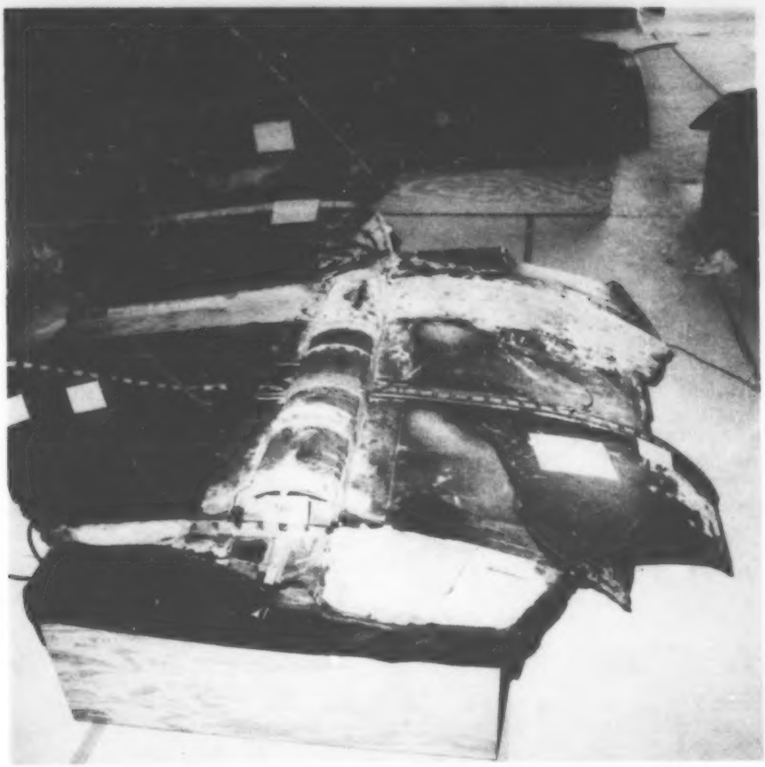

OUTER SURFACE SOOTED VERY DARK
URETHANE FOAM
58.8"
STIFF STUB
SYSTEM TUNNEL
STIFF/STIFF FACTORY JOINT
PIN RETAINER
P/N 1U50715-02
S/N 0000001R2
OUTER CLEVIS LEG
46 HOLES
2 HALF HOLES
TUNNEL LENGTH 71.4"
9 HOLES
118°
42°
170.4"
CABLE
AFT
STIFFENER STUB
FWD STUB
58.4"
URETHANE FOAM
126"
67.2"
67.2"
INACTIVE STIFFENER STUB
66"
16 HOLES
FACTORY JOINT
26 HOLES
CLEVIS INNER LEG
1 HALF HOLE.
OUTER LEG
MISSING
86°
118°
140°
P/N 1U50715-02
S/N 0000002R2
R.H. FWD STIFF

Figure 38. Contact 21-3, RH Aft Segment, Stiff/Stiff Joint



Photograh 23. Contact 21-3, RH Aft Segment, Stiff/Stiff Joint

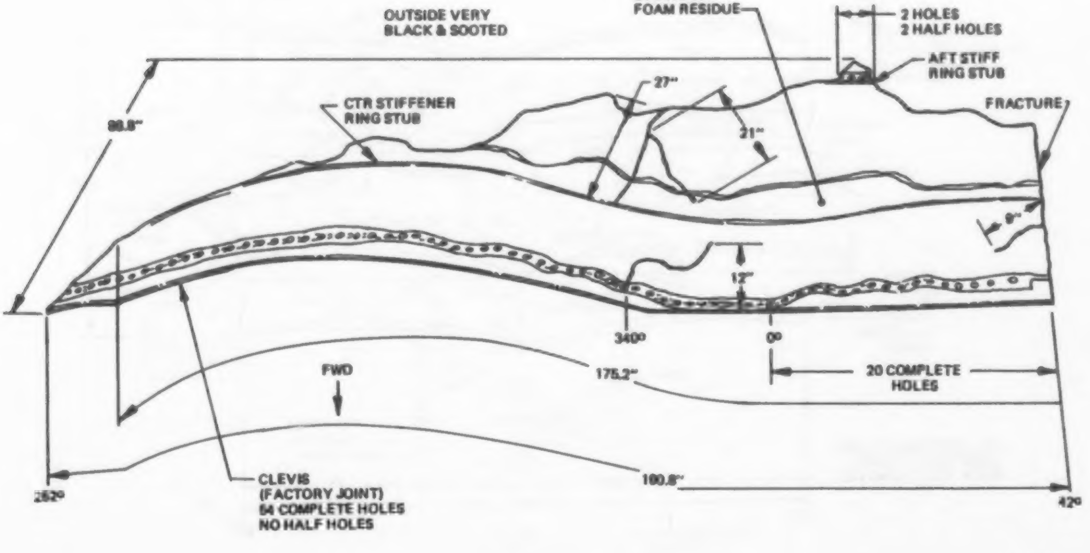
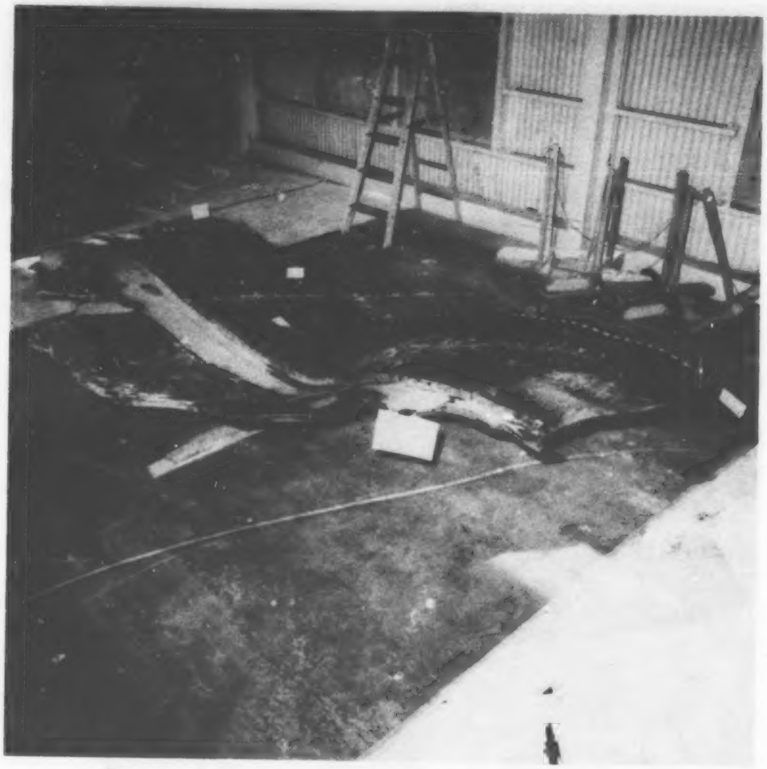

OUTSIDE VERY
BLACK & SOOTED
URETHANE
FOAM RESIDUE
2 HOLES
2 HALF HOLES
AFT STIFF
RING STUB
FRACTURE
CTR STIFFENER
RING STUB
98.8"
27"
21"
9"
12"
340°
0°
FWD
175.2"
20 COMPLETE
HOLES
252°
CLEVIS
(FACTORY JOINT)
54 COMPLETE HOLES
NO HALF HOLES
190.8"
42°

Figure 39. Contact 21-4, RH Aft Segment, Aft Stiffener



Photograph 24. Contact 21-4, RH Aft Segment, Aft Stiffener

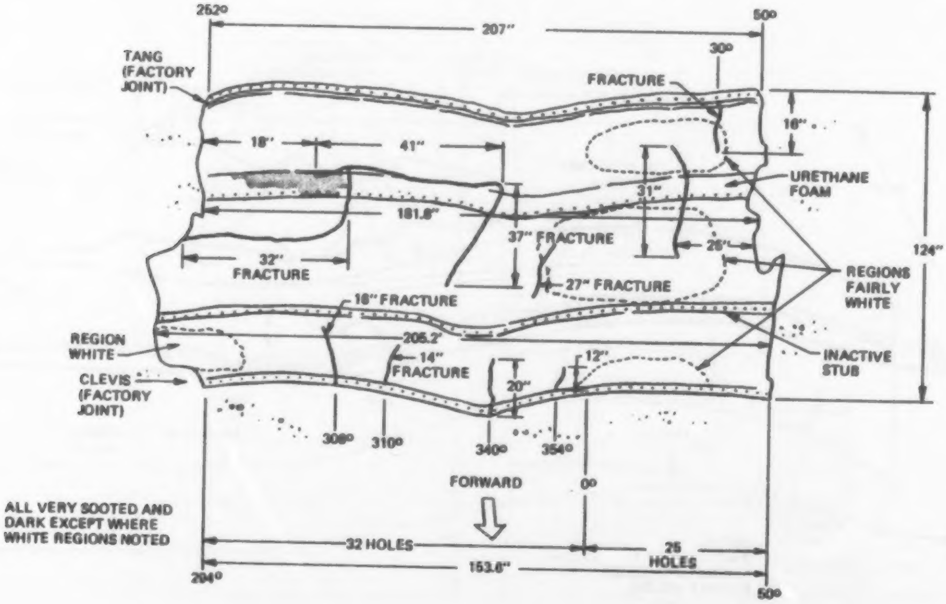
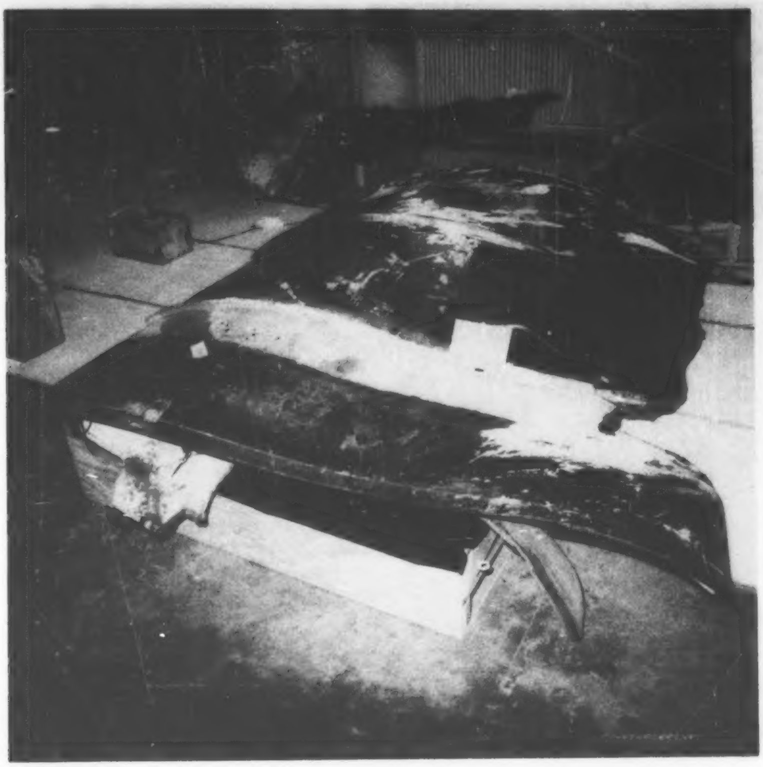

252°
207"
50°
30°
TANG (FACTORY JOINT)
FRACTURE
18"
41"
16"
URETHANE FOAM
31"
181.8"
37" FRACTURE
26"
124"
32" FRACTURE
27" FRACTURE
REGIONS FAIRLY WHITE
18" FRACTURE
REGION WHITE
205.2"
14" FRACTURE
12"
INACTIVE STUB
CLEVIS (FACTORY JOINT)
20"
308°
310°
340°
354°
FORWARD
0°
ALL VERY SOOTED AND DARK EXCEPT WHERE WHITE REGIONS NOTED
32 HOLES
25 HOLES
153.6"
294°
50°

Figure 40. Contact 21-5, RH Aft Segment, Forward Stiffener



Photograph 25. Contact 21-5, RH Aft Segment, Forward Stiffener

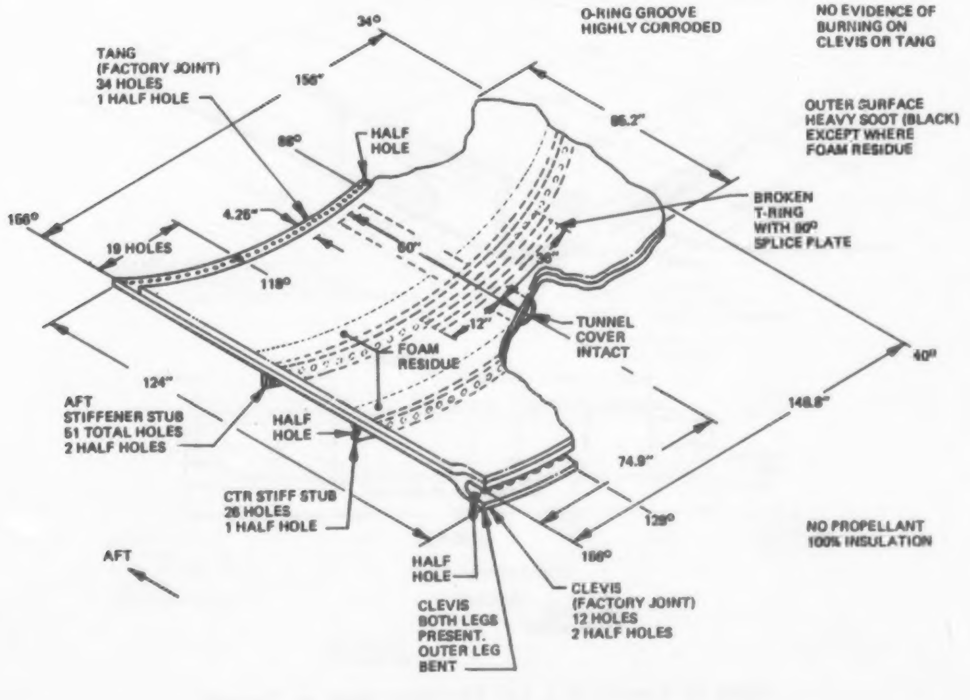
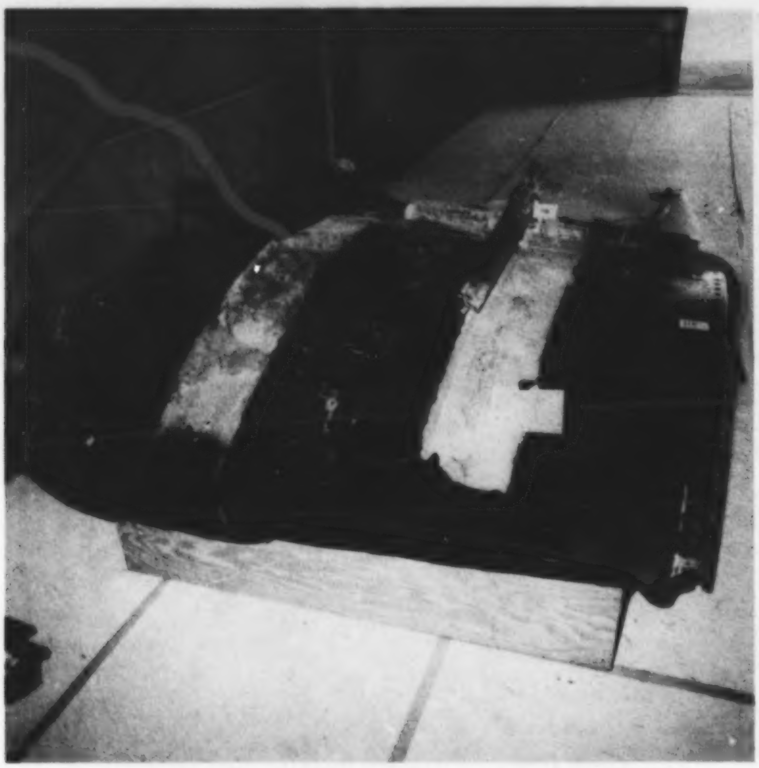

34°
O-RING GROOVE HIGHLY CORRODED
NO EVIDENCE OF BURNING ON CLEVIS OR TANG
TANG (FACTORY JOINT) 34 HOLES 1 HALF HOLE
156"
86.2"
OUTER SURFACE HEAVY SOOT (BLACK) EXCEPT WHERE FOAM RESIDUE
88°
HALF HOLE
166°
4.25"
19 HOLES
118°
60"
36"
BROKEN T-RING WITH 90° SPLICE PLATE
12"
TUNNEL COVER INTACT
FOAM RESIDUE
40°
124"
AFT STIFFENER STUB 51 TOTAL HOLES 2 HALF HOLES
HALF HOLE
148.8"
74.9"
CTR STIFF STUB 26 HOLES 1 HALF HOLE
129°
NO PROPELLANT 100% INSULATION
AFT
HALF HOLE
166°
CLEVIS (FACTORY JOINT) 12 HOLES 2 HALF HOLES
CLEVIS BOTH LEGS PRESENT. OUTER LEG BENT

Figure 41. Contact 21-9, RH Aft Segment, Aft Stiffener



Photograph 26. Contact 21-9, RH Aft Segment, Aft Stiffener

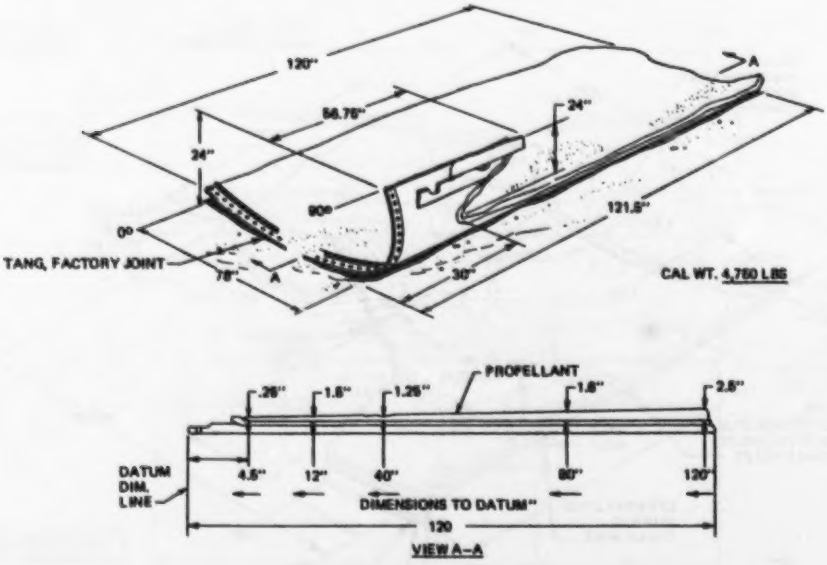
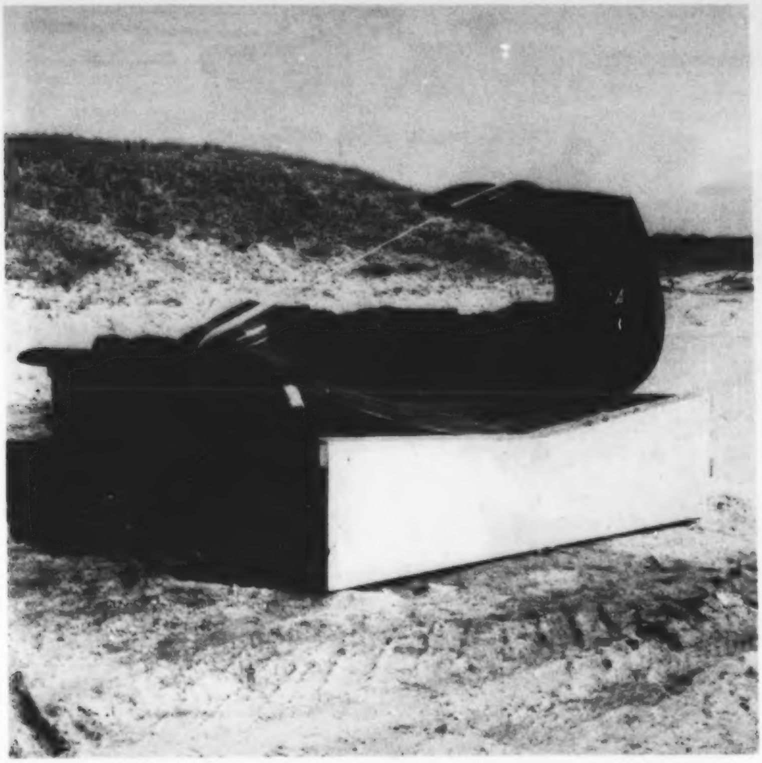

120"
56.75"
24"
24"
90°
0°
121.5"
TANG, FACTORY JOINT
78"
A
30"
A
CAL WT. 4,760 LBS
PROPELLANT
.25"
1.5"
1.25"
1.5"
2.5"
DATUM DIM. LINE
4.5"
12"
40"
80"
120"
DIMENSIONS TO DATUM"
120
VIEW A–A
P/N 1U50131
S/N 0000075R1

Figure 42. Contact 26-1, LH Aft Center Segment, Forward Cylinder



Photograph 27. Contact 26-1, LH Aft Center Segment, Forward Cylinder

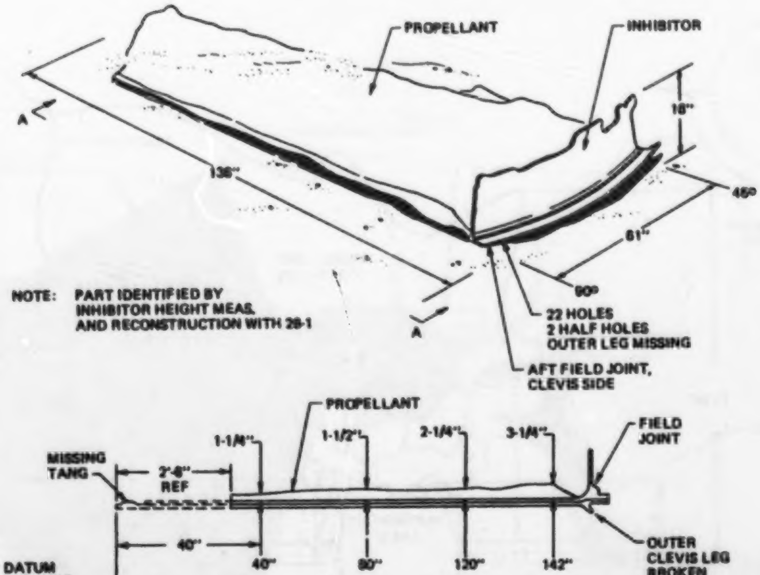
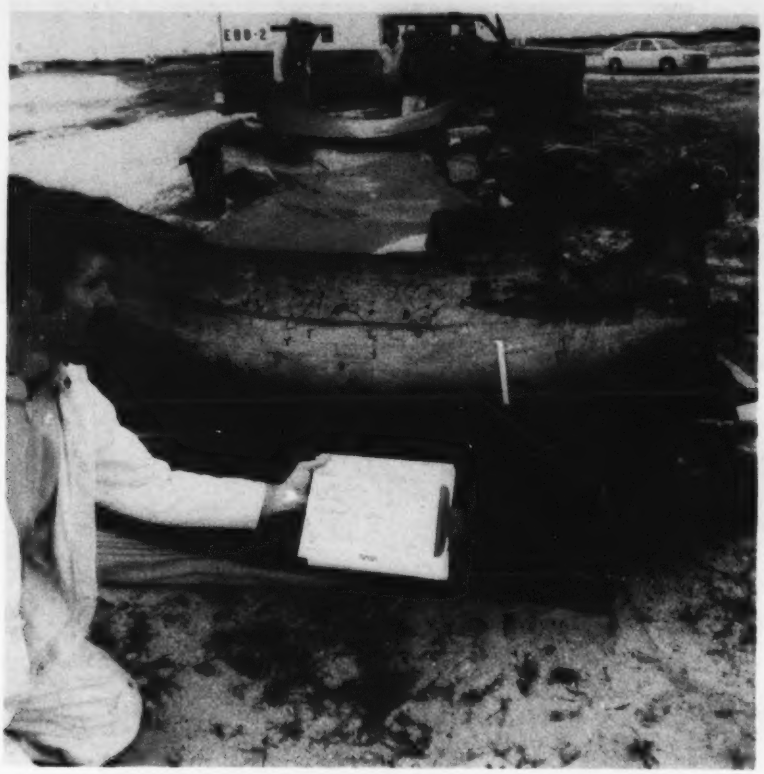

PROPELLANT
INHIBITOR
A
18"
136"
45°
61"
90°
NOTE: PART IDENTIFIED BY INHIBITOR HEIGHT MEAS. AND RECONSTRUCTION WITH 26-1
A
22 HOLES
2 HALF HOLES
OUTER LEG MISSING
AFT FIELD JOINT, CLEVIS SIDE
PROPELLANT
1-1/4"
1-1/2"
2-1/4"
3-1/4"
FIELD JOINT
MISSING TANG
2'-6" REF
40"
40"
80"
120"
142"
OUTER CLEVIS LEG BROKEN
DATUM DIM. LINE (SAME DATUM USED ON MATCHING PIECE)
DIMENSIONS TO DATUM
VIEW A–A
P/N 1U50131
S/N 0000075R1

Figure 43. Contact 26-2, LH Aft Center Segment, Forward Cylinder



Photograph 28. Contact 26-2, LH Aft Center Segment, Forward Cylinder

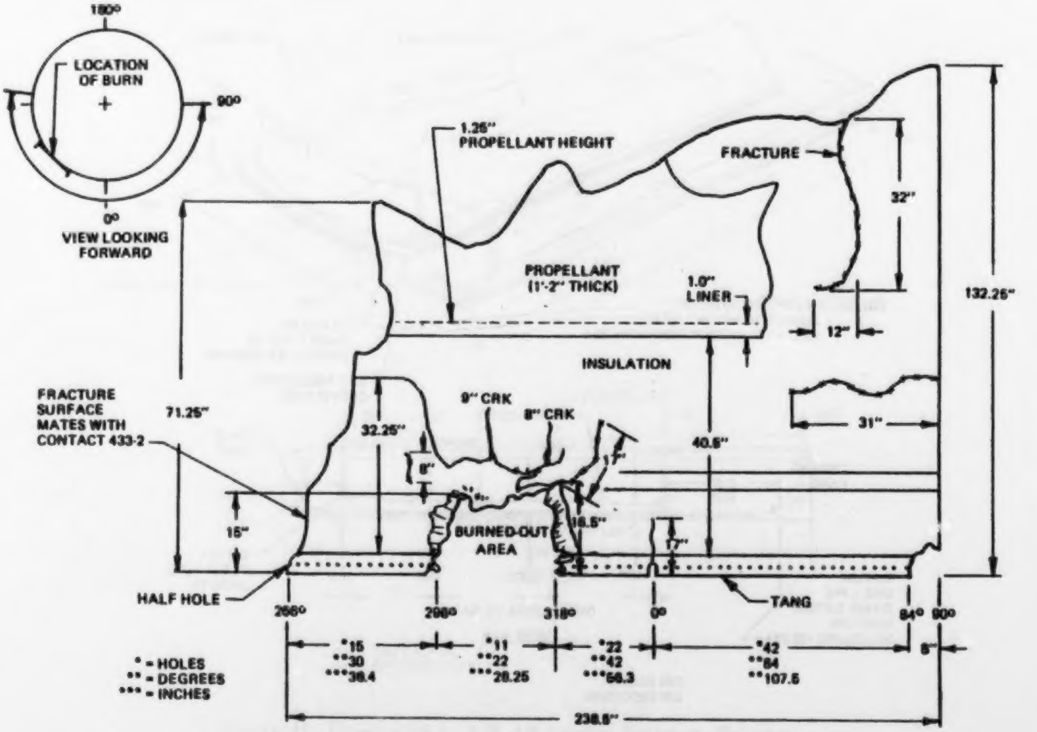

180°
LOCATION OF BURN
90°
0°
VIEW LOOKING FORWARD
1.25" PROPELLANT HEIGHT
FRACTURE
32"
PROPELLANT (1'-2" THICK)
1.0" LINER
12"
132.25"
INSULATION
FRACTURE SURFACE MATES WITH CONTACT 433-2
71.25"
32.25"
9" CRK
8" CRK
8"
17"
40.5"
31"
15"
BURNED-OUT AREA
16.5"
17"
HALF HOLE
TANG
266°
296°
318°
0°
84°
90°
*15
**30
***38.4
*11
**22
***28.25
*22
**42
***56.3
*42
**84
**107.5
5"
* = HOLES
** = DEGREES
*** = INCHES
238.5"

Figure 44. Contact 131, RH Aft Center Segment, Aft Cylinder Dimensional Outside View

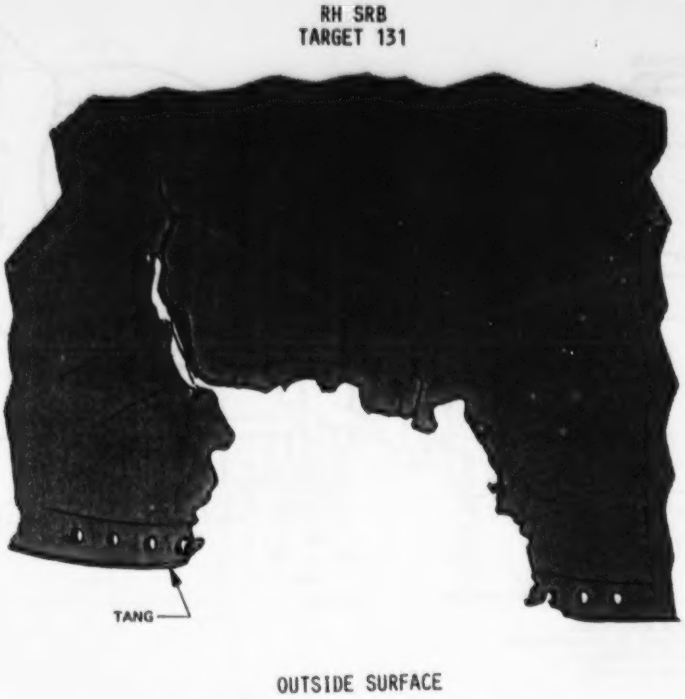

RH SRB
TARGET 131
TANG
OUTSIDE SURFACE

Figure 45. Contact 131, Outside Surface

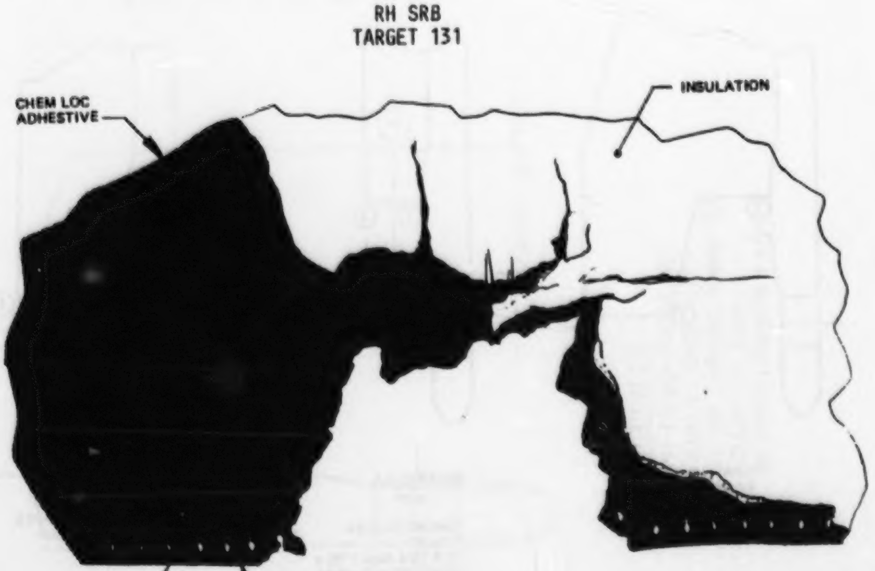
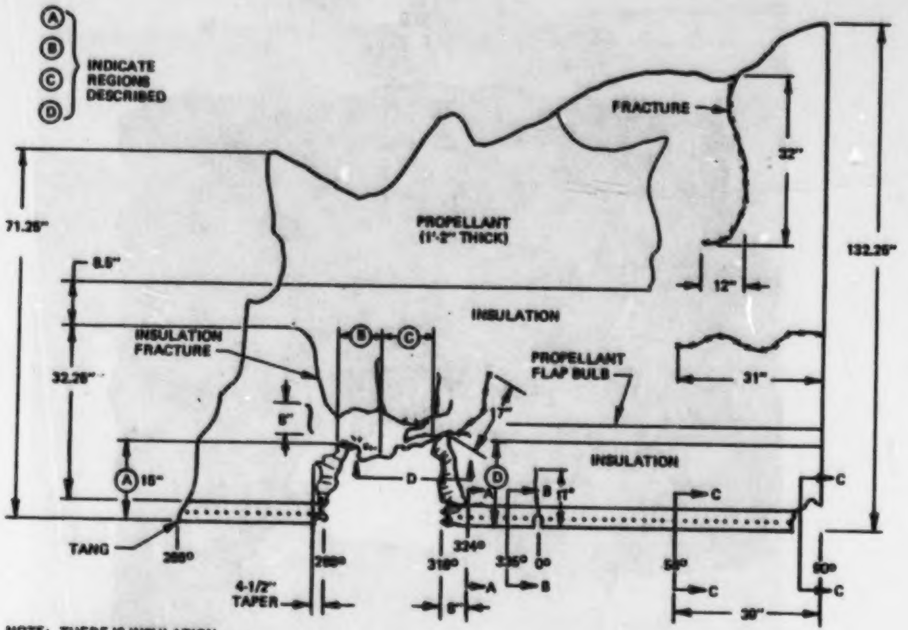
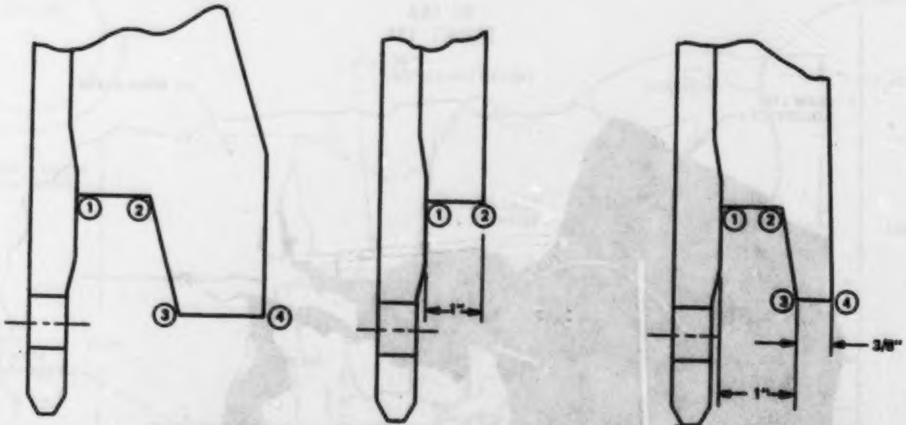

RH SRB
TARGET 131
CHEM LOC ADHESIVE
INSULATION
BARE METAL
TANG

Figure 46. Contact 131, Inside Surface View of Burned Area


Ⓐ
Ⓑ
Ⓒ
Ⓓ
INDICATE REGIONS DESCRIBED
FRACTURE
32"
PROPELLANT (1'-2" THICK)
71.26"
132.26"
8.5"
12"
INSULATION
INSULATION FRACTURE
32.26"
PROPELLANT FLAP BULB
31"
6"
1"
INSULATION
D
Ⓐ 15"
A
B
11"
C
TANG
288°
298°
324°
318°
335°
0°
50°
90°
4-1/2" TAPER
6"
30"

NOTE: THERE IS INSULATION DE-BONDING FROM 318° TO 90°. IT IS NOT ATTACHED AS SHOWN IN SECTIONS

Figure 47. Contact 131, Aft Center Segment, Aft Cylinder Inside Dimensional View

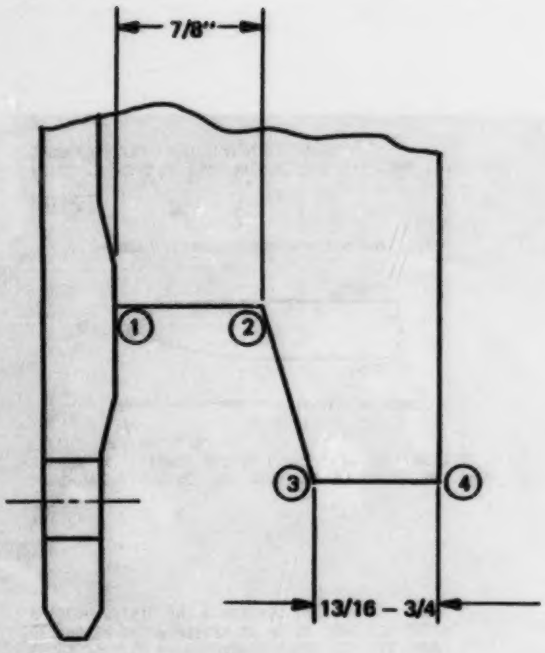


ORIGINAL DESIGN

SECTION A-A
324°
TAPERS TO 318°
TO 0.0"
PT 3 TO 4 AND 2 TO 3
NONEXISTANT HERE

SECTION B-B
335°
PTS 3 AND 4 TAPER
TO 0.0" AT 324°

Figure 48. Contact 131, Insulation Profile


7/8"
①
②
③
④
13/16 – 3/4
2"
①
INSULATION
D6AC

SECTION C-C
58° TO 90° REMAINS
FAIRLY CONSTANT;
AT 58° TAPERS DOWN
TO 3/8" AT 335°
BETWEEN POINTS 3 AND 4

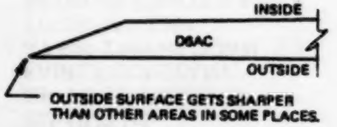
SECTION D-D
CROSS SECTION FOLLOWS
METAL EDGE CONTOUR
UP TO PROPELLANT FLAP BULB

Figure 49. Contact 131, Insulation Profile

REGION A

INSIDE

METAL IS NOT SMOOTH, AND EDGES ARE BENT IN SOME AREAS DUE TO IMPACT. IT HAS SHARPER EDGES AND HAS 4 1/2" TAPER REGION THAT HAS RUTS AND IS ROUGH.


INSIDE
DSAC
OUTSIDE
OUTSIDE SURFACE GETS SHARPER THAN OTHER AREAS IN SOME PLACES.

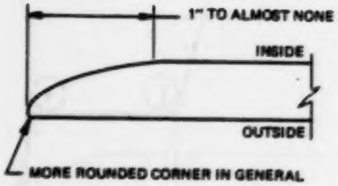
OUTSIDE

EDGES TWISTED WITH SHARPER EDGES AND HAS SOME BENT-OVER SHARP PIECES OF METAL SOME CORROSION, BUBBLED PAINT, AND BLACKENED AREAS.

REGION B

INSIDE

ROUGH METAL SURFACE BUT STARTING TO SMOOTH OUT FROM REGION 'A'. TAPER NOT AS LARGE - 1" TO ALMOST NO TAPER, ONLY ROUNDED.


1" TO ALMOST NONE
INSIDE
OUTSIDE
MORE ROUNDED CORNER IN GENERAL

OUTSIDE

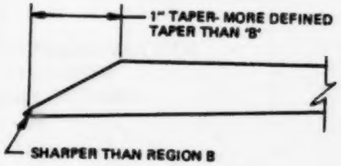
METAL IS ROUGHER THAN AREA C, AND HAS SOME CORROSION, BUBBLED PAINT, AND BLACKENED AREAS.

Figure 50. Contact 131, Segment Wall Profile

REGION C

INSIDE

THIS REGION INSULATION IS PRESENT AND FOLLOWS CONTOUR OF METAL. TAPER BECOMES SMOOTHER THAN 'B' OUTSIDE EDGE BECOMES SHARPER MORE POINTED.


1" TAPER- MORE DEFINED TAPER THAN 'B'
SHARPER THAN REGION B

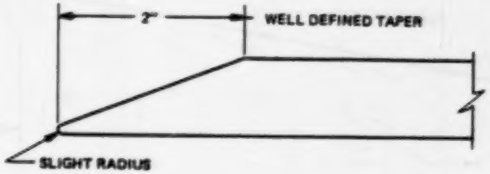
OUTSIDE

FAIRLY SMOOTH SURFACE, SHOWS SOME CORROSION, BUBBLED PAINT, AND BLACKENED AREAS.

REGION D

INSIDE

THIS REGION INSULATION IS PRESENT AND FOLLOWS CONTOUR OF METAL. TAPER IS VERY SMOOTH WITH 1/8" TAPERED EDGE (SLIGHT RADIUS).


2"
WELL DEFINED TAPER
SLIGHT RADIUS

OUTSIDE

METAL IS FAIRLY SMOOTH AND HAS CORROSION ON IT. IT HAS A RUSTY COLOR BUT NO BUBBLED PAINT AS IN REGIONS 'A', 'B', AND 'C'.

Figure 51. Contact 131, Segment, Wall Profile

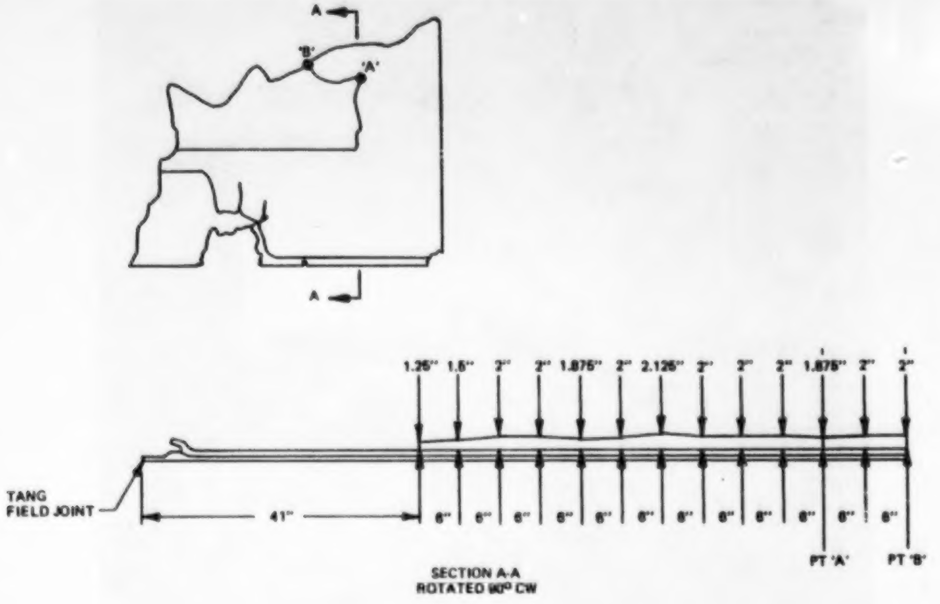
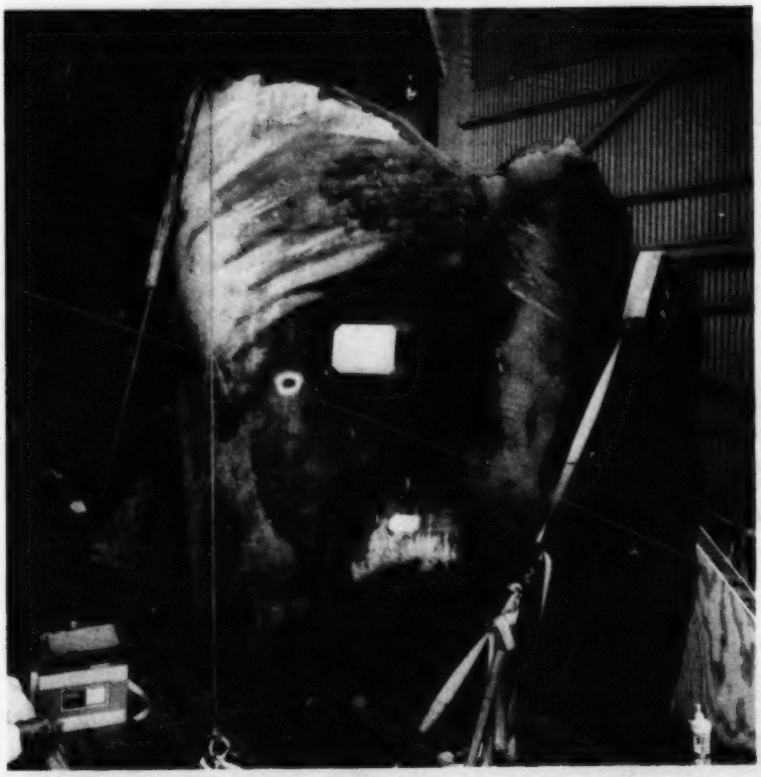
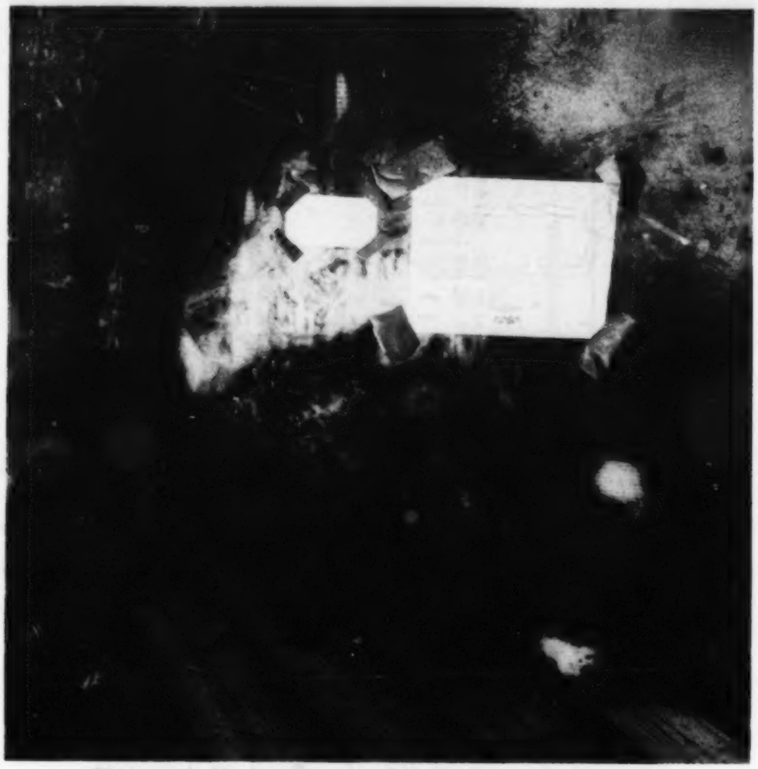

A
'B'
'A'
A
1.25"
1.5"
2"
2"
1.875"
2"
2.125"
2"
2"
2"
1.875"
2"
2"
TANG
FIELD JOINT
41"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
PT 'A'
PT 'B'
SECTION A-A
ROTATED 90° CW

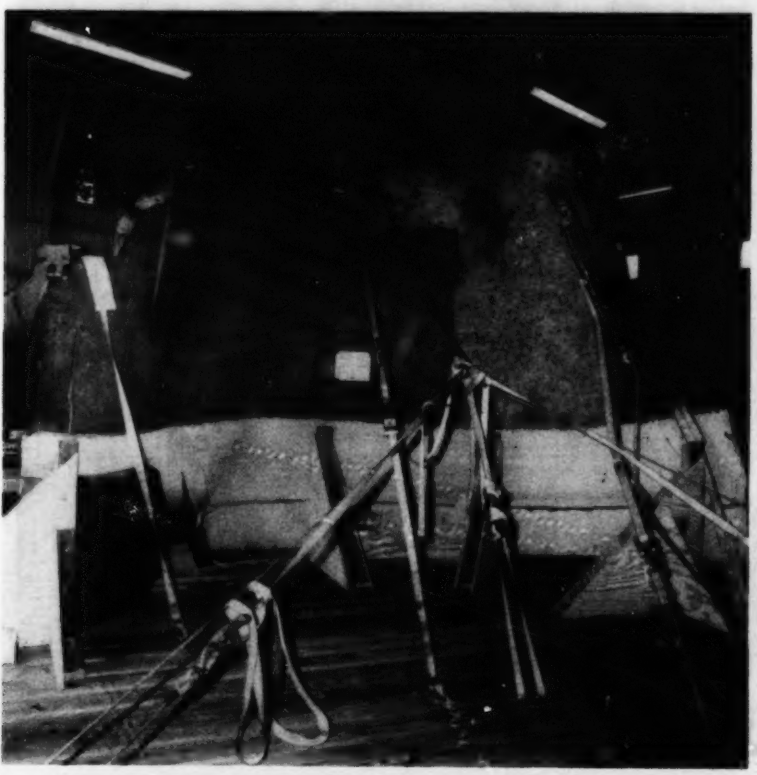
Figure 52. Contact 131, Propellant Profile



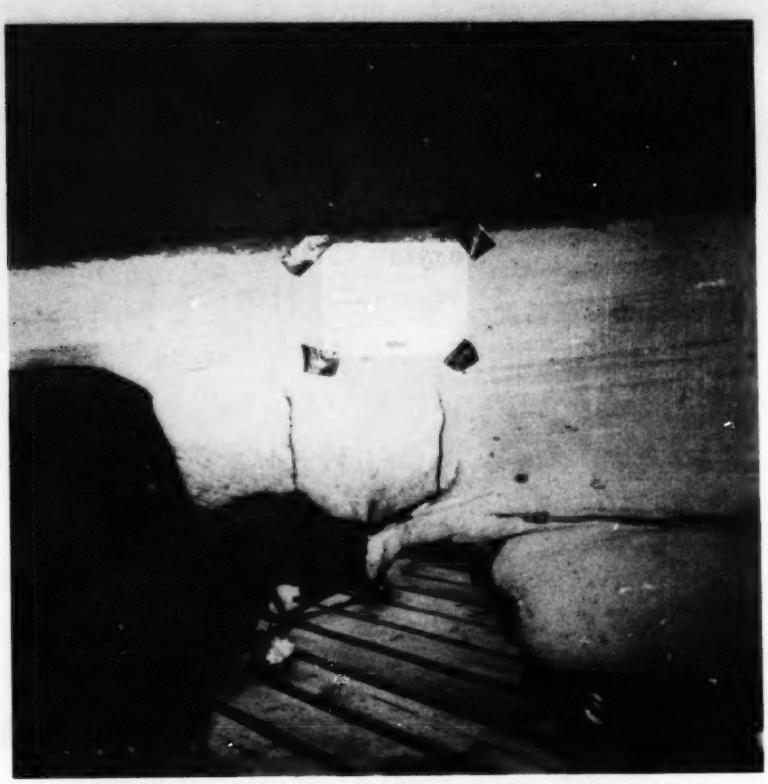
Photograph 29. Contact 131, RH Aft Center Segment, Aft Cylinder Outside View



Photograph 30. Contact 131, RH Aft Center Segment, Aft Cylinder Outside Closeup View



Photograph 31. Contact 131, RH Aft Center Segment, Aft Cylinder Inside View



Photograph 32. Contact 131, RH Aft Center Segment, Aft Cylinder Inside Closeup View

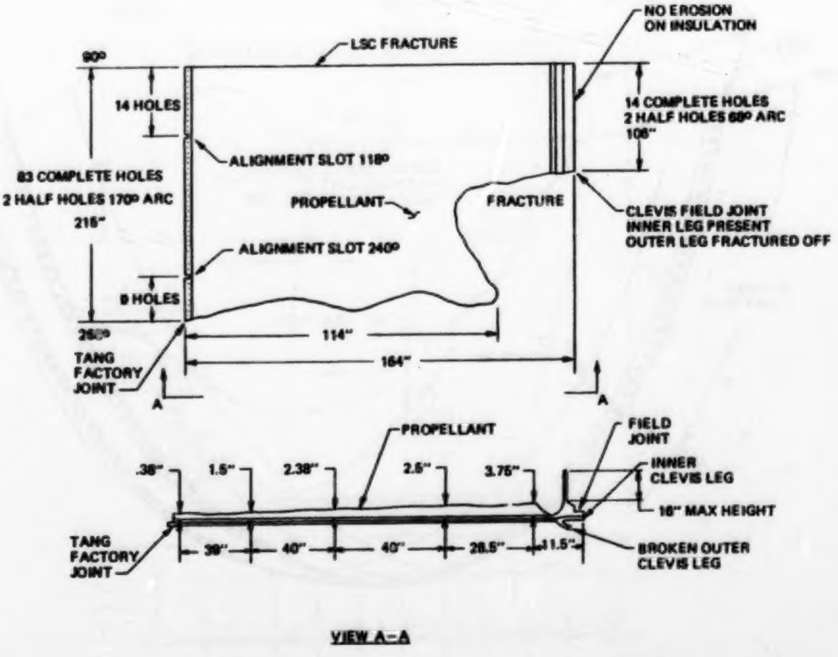

NO EROSION ON INSULATION
LSC FRACTURE
90°
14 HOLES
14 COMPLETE HOLES
2 HALF HOLES 68° ARC
106"
ALIGNMENT SLOT 118°
83 COMPLETE HOLES
2 HALF HOLES 170° ARC
215"
PROPELLANT
FRACTURE
CLEVIS FIELD JOINT
INNER LEG PRESENT
OUTER LEG FRACTURED OFF
ALIGNMENT SLOT 240°
9 HOLES
260°
114"
164"
TANG FACTORY JOINT
A
A
PROPELLANT
FIELD JOINT
.38"
1.5"
2.38"
2.5"
3.75"
INNER CLEVIS LEG
16" MAX HEIGHT
TANG FACTORY JOINT
38"
40"
40"
28.5"
11.5"
BROKEN OUTER CLEVIS LEG
VIEW A–A

Figure 53. Contact 195, Forward Center Segment, Forward Cylinder

Photograph 33. Contact 195, Forward Center Segment, Forward Cylinder

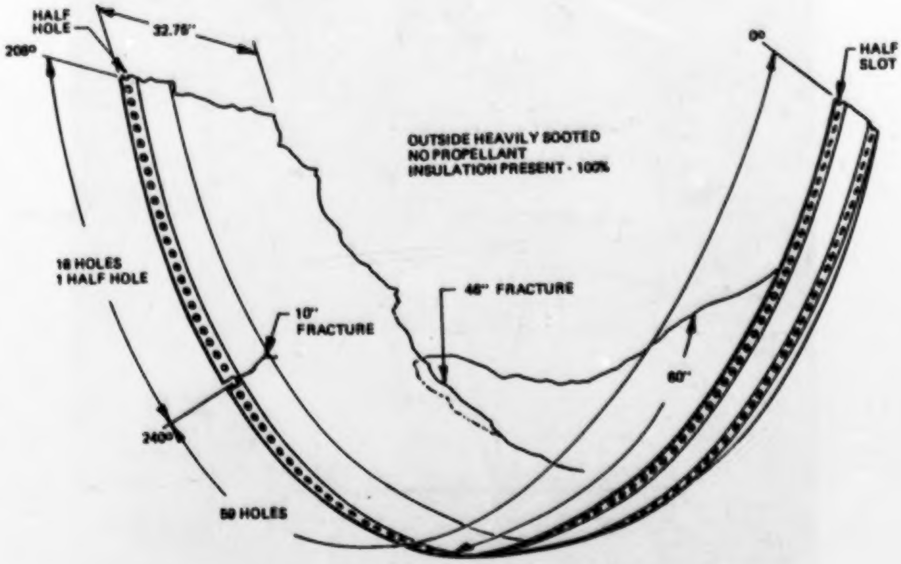
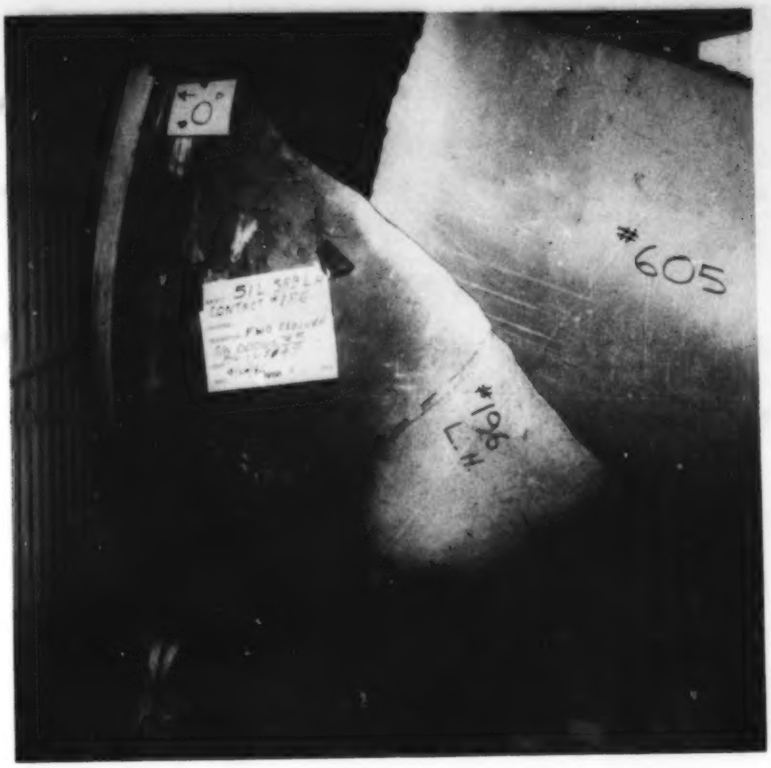

HALF HOLE
208°
32.78"
0°
HALF SLOT
OUTSIDE HEAVILY SOOTED
NO PROPELLANT
INSULATION PRESENT - 100%
18 HOLES
1 HALF HOLE
46" FRACTURE
10" FRACTURE
60"
240°
59 HOLES

Figure 54. Contact 196, LH Forward Dome


O
#605
#196
LH
51L

Photograph 34. Contact 195, LH Forward Segment, Forward Dome

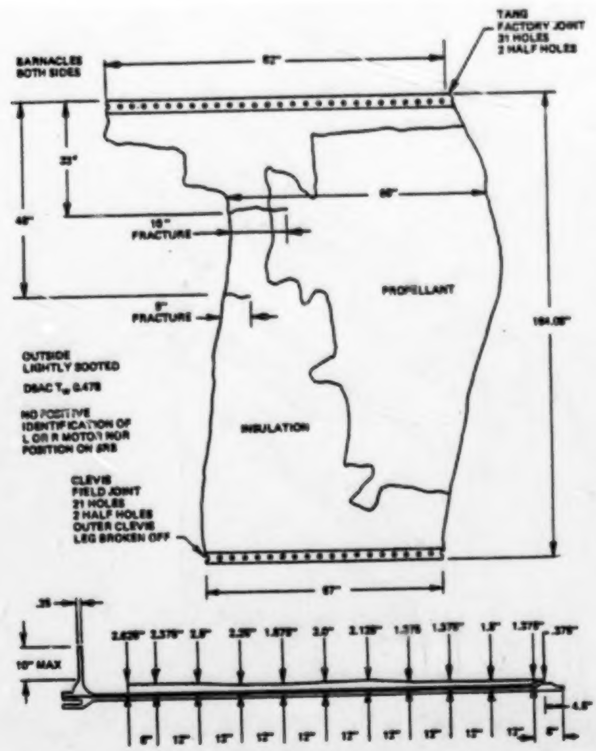

TANG
FACTORY JOINT
21 HOLES
2 HALF HOLES
BARNACLES
BOTH SIDES
62"
23"
48"
66"
10"
FRACTURE
9"
FRACTURE
PROPELLANT
164.08"
OUTSIDE
LIGHTLY SOOTED
D6AC T_m 0.478
NO POSITIVE
IDENTIFICATION OF
L OR R MOTOR NOR
POSITION ON SRB
INSULATION
CLEVIS
FIELD JOINT
21 HOLES
2 HALF HOLES
OUTER CLEVIS
LEG BROKEN OFF
67"
.25
10" MAX
2.625"
2.375"
2.5"
2.25"
1.875"
2.0"
2.125"
1.375
1.375"
1.5"
1.375"
.375"
4.5"
6"
12"
12"
12"
12"
12"
12"
12"
12"
12"
6"

Figure 55. Contact 214, Case Cylinder Fragment

Photograph 35. Contact 214, Case Cylinder Fragment

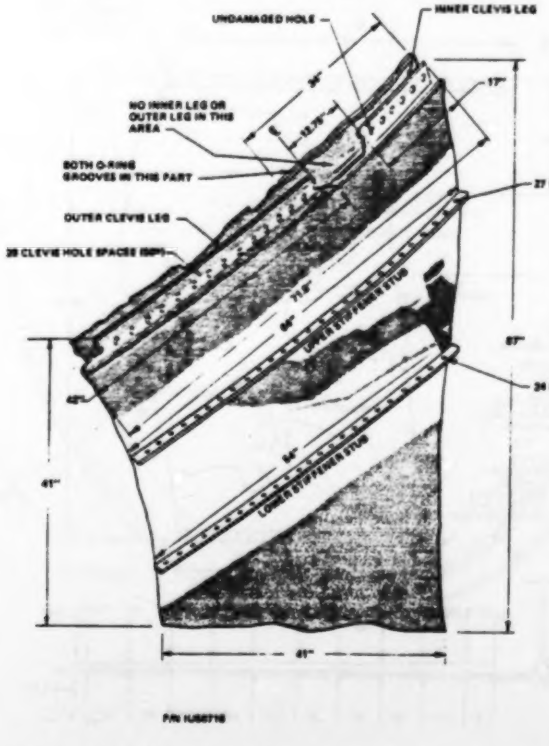

UNDAMAGED HOLE
INNER CLEVIS LEG
34"
17"
NO INNER LEG OR OUTER LEG IN THIS AREA
12.75"
BOTH O-RING GROOVES IN THIS PART
27 FULL HOLES
OUTER CLEVIS LEG
28 CLEVIS HOLE SPACES
71.5"
64"
UPPER STIFFENER STUB
87"
24 FULL HOLES
42"
54"
LOWER STIFFENER STUB
41"
41"
P/N 1U50716

Figure 56. Contact 292, LH Aft Segment Aft ET Attach, Outside View

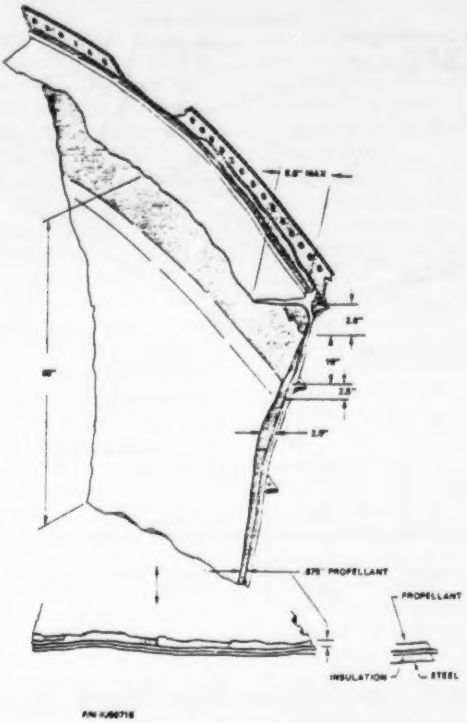
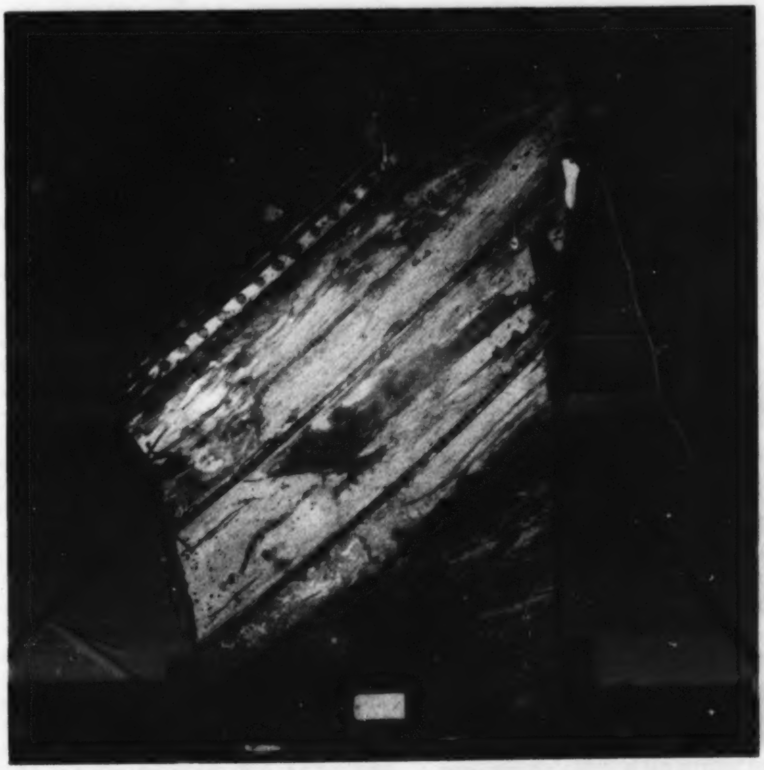

2.8"
10"
2.8"
2.8"
.375" PROPELLANT
PROPELLANT
INSULATION
STEEL

Figure 57. Contact 292, LH Aft Segment, Aft ET Attach, Outside View



Photograph 36. Contact 292, LH Aft Segment, AFT ET Attach

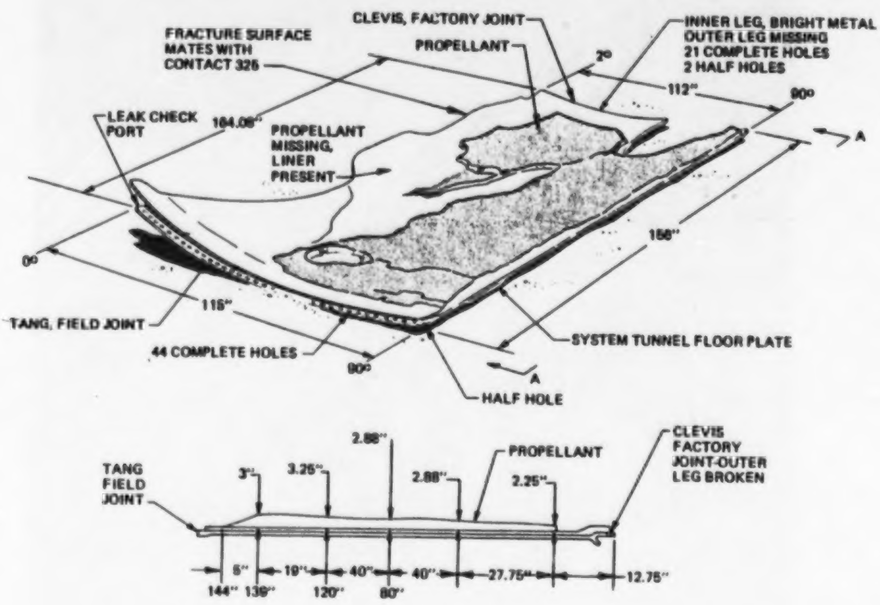
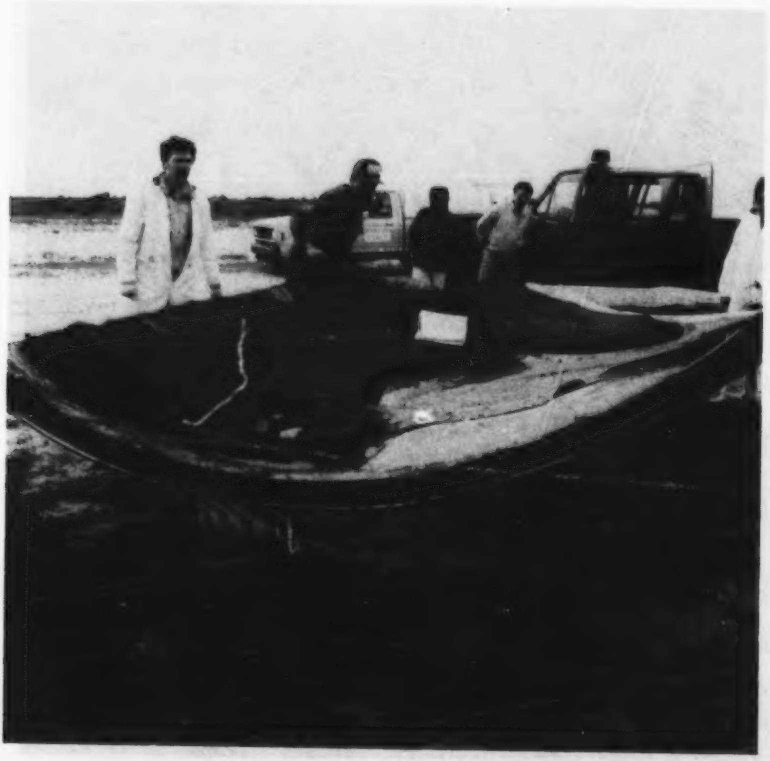

CLEVIS, FACTORY JOINT
FRACTURE SURFACE MATES WITH CONTACT 326
PROPELLANT
INNER LEG, BRIGHT METAL
OUTER LEG MISSING
21 COMPLETE HOLES
2 HALF HOLES
2°
112"
90°
A
LEAK CHECK PORT
184.06"
PROPELLANT MISSING, LINER PRESENT
158"
0°
115"
TANG, FIELD JOINT
44 COMPLETE HOLES
90°
SYSTEM TUNNEL FLOOR PLATE
A
HALF HOLE
2.88"
PROPELLANT
CLEVIS FACTORY JOINT-OUTER LEG BROKEN
TANG FIELD JOINT
3"
3.25"
2.88"
2.25"
5"
19"
40"
40"
27.75"
12.75"
144"
139"
120"
80"

Figure 58. Contact 301, RH Forward Segment, Aft Cylinder



Photograph 37. Contact 301, RH Forward Segment, Aft Cylinder

CONTACT #325—This part has been identified as an aft cylinder of a forward segment, RH. Identification was made from the insulation erosion pattern on the clevis end of the part. Also, the fracture surface mates with contact 301, which has been identified as RH by part number and serial number found on the exterior surface. There is no propellant on the part. The outside surface is moderately clean with no soot. (Reference Figure 59 and Photograph 38.)

CONTACT #433—This part has been identified as the forward cylinder of an aft center segment (LH or RH unknown). Identification was made by inhibitor height measurement. There is no propellant on the part and the inside surface has 100% coverage of insulation and liner. (Reference Figure 60 and Photograph 39.)

CONTACT #433-1—This part has been identified as the aft cylinder of the aft center segment, RH SRB. It mates physically at fracture surfaces with Contact 433-2 (Contact 433-2 has been positively identified as RH SRB). The inboard surface is covered 100% with insulation and approximately 50% coverage of propellant. (Reference Figure 61 and Photograph 40.)

CONTRACT #433-2—This part has been identified as an aft cylinder fragment from the aft center segment, RH SRB. The part physically mates at the fracture surface with Contact 131. Contact 131 has been identified by serial number to be RH SRB. Propellant covers approximately 70% of the surface. (Reference Figure 62 and Photograph 41.)

CONTACT #468—This part has been identified as an aft cylinder forward segment (LH or RH unknown). Identification was made by analysis of the propellant burn back pattern. There are no other apparent identifying features present with exception of the 118° alignment slot located on the tang. (Reference Figure 63 and Photograph 42.)

CONTACT #487—This part has been identified as a fragment of the forward skirt clevis joint. It is made of aluminum and has the rubber crotch seal attached. No determination as to RH or LH SRB has been made. (Reference Figure 64 and Photograph 43.)

CONTACT #502—This part has been identified as a section of the aft cylinder, forward center segment, RH SRB. Identification was by serial number (0000106) and part number (1U50717-02) found on the exterior surface. There is propellant covering approximately 70% of the part. (Reference Figure 65 and Photographs 44 and 45.)

CONTACT #524—This part has been identified as a fragment of a case cylinder segment. There is no evidence to establish whether it is RH or LH SRB. Propellant covers about 90% of the surface. (Reference Figure 66 and Photograph 46.)

CONTACT #538—This part has been identified as the RH forward skirt with frustum separation ordnance ring and parachutes attached. It was identified by the paint pattern on the exterior surface and the serial number located on the ordnance ring. (Reference Photograph 47.)

CONTACT #538—A part identified as a Rate Gyro assembly, RH SRB, was retrieved from the impact area adjacent to the forward skirt; therefore, the Rate Gyro and the forward skirt were assigned identical Contact Numbers. The part was identified by part number and serial number found on the identification plate.

CONTACT #579—This part has been identified as a fragment of the attach segment, aft segment, RH SRB. Identification was made by serial number (0000006R2) found on the exterior surface. Further identification was made by inhibitor height and propellant profile analysis. The part physically mates with Contact 292 at the fracture surface. Propellant covers approximately 95% of the interior surface. This part is considered a significant find since it is a section of the failed joint. No heat damage or other unusual conditions were noted on the part. (Reference Figure 67 and Photographs 48 and 49.)

CONTACT #605—This part has been identified as a fragment of a forward cylinder, forward segment (LH or RH unknown). A small island of propellant was noted on the piece before recovery but was displaced and lost during the retrieval operation. There are no other apparent identifying features present. (Reference Figure 68 and Photograph 50.)

CONTACT #615-1A—This part has been identified as a fragment of forward cylinder, forward center segment, RH SRB. Identification was made by dimensional analysis which showed that the part physically mates with Contact 615-2 (615-2 was identified by serial number found on the part). This part has propellant covering approximately 80% of the interior surface. (Reference Figure 69 and Photograph 51).

CONTACT #615-1B—this part has been identified as a fragment of a forward cylinder, forward center segment, RH SRB. Identification was based on the fact that the part physically mates with Contact 615-1A at the fracture surface. Contact 615-1A has been identified as RH SRB. The interior surface of 615-1B has approximately 75% propellant coverage. (Reference Figure 70 and Photograph 52.)

CONTACT #615-2—This part has been identified as a fragment of a forward cylinder, forward center segment, RH SRB. Identification was made by part number (1U50715) and serial number (000028R2) found on the exterior surface. The interior surface of the part has approximately 60% propellant coverage. (Reference Figure 71 and Photograph 53).

CONTACT #615-3—This part has been identified as a fragment of the aft stiffener segment, aft segment, RH SRB. Identification was made by the fact that the part physically mates with Contacts 21-1 and 21-4 at the fracture surfaces. Contact 21-1 has been identified by serial number as RH SRB. No propellant was found on the part. (Reference Figure 72 and Photograph 54.)

CONTACT #615-4—This part has been identified as a small fragment of a case cylinder. There are no identifying features present which can be used to obtain further definition. There is no propellant on the part. (Reference Figure 73 and Photograph 55.)

CONTACT #631—This part has been identified as a fragment of a forward cylinder, of either a forward center or aft center segment (LH or RH unknown). Identification was made by segment length dimension, membrane wall thickness, and presence of a clevis field joint. Propellant covers approximately 75% of the interior surface. (Reference Figure 74 and Photograph 56.)

CONTACT #635—This part has been identified as a fragment of a forward cylinder, forward segment, LH SRB. Identification was made from tang thickness measurement which matched manufacturing records of the part. No propellant is present. (Reference Figure 75 and Photograph 40.)

CONTACT #699—This part has been identified as a fragment of an aft cylinder, forward center segment, RH SRB. Identification was made by part number (1U50717) and serial number (0000106) found on the exterior surface. The interior surface of the part has approximately 80% propellant coverage. (Reference Figure 76 and Photograph 57.)

CONTACT #711—This part has been identified as a fragment of a forward dome with forward skirt clevis attached. LH or RH SRB is unknown. There is no propellant on the part and no other identifying features are apparent. (Reference Figure 77 and Photograph 58.)

CONTACT #712—This part has been identified as a part of the RH SRB attach segment of the aft segment. Identification was made by bushings found installed in the aft attach stub holes located at 268° and 209° which were traced through manufacturing records. Records indicated that bushings were used to repair holes at the exact location as found on the recovered part. Further confirmation was made by determining that the burned out area was consistent with in-flight photographic evidence (291° to 318°). The circumferential location was determined by relationship between unmarked alignment slot found on the tang to the unique hole pattern found on the aft attach stub. The relationship proved that the tang alignment slot was located at 240°. Approximately 80% of the interior surface was covered with propellant. (Reference Figures 78, 79, and 80, and Photographs 59 through 62.)

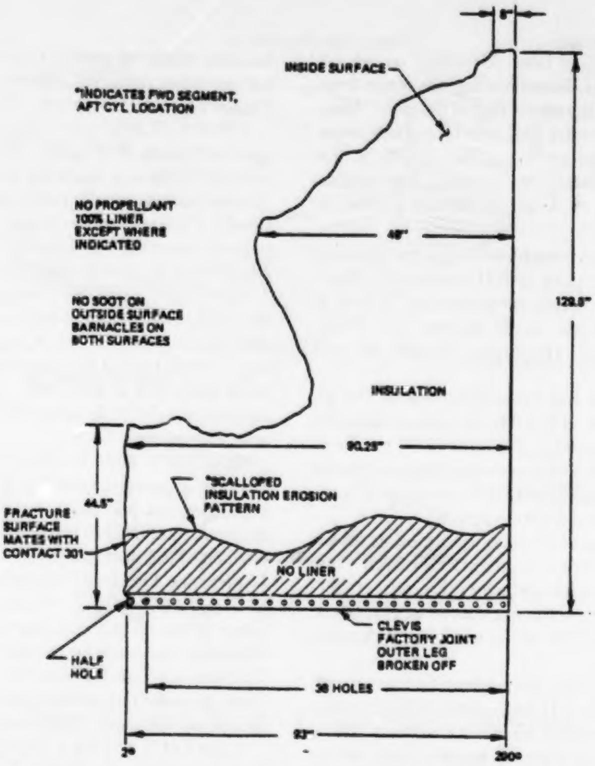

*INDICATES FWD SEGMENT, AFT CYL LOCATION
INSIDE SURFACE
8"
NO PROPELLANT
100% LINER
EXCEPT WHERE
INDICATED
48"
129.8"
NO SOOT ON
OUTSIDE SURFACE
BARNACLES ON
BOTH SURFACES
INSULATION
90.25"
44.5"
*SCALLOPED
INSULATION EROSION
PATTERN
FRACTURE
SURFACE
MATES WITH
CONTACT 301
NO LINER
CLEVIS
FACTORY JOINT
OUTER LEG
BROKEN OFF
HALF
HOLE
38 HOLES
93"
2°
290°

Figure 59. Contact 325, RH Forward Segment, Aft Cylinder

Photograph 38. Contact 325, RH Forward Segment, Aft Cylinder

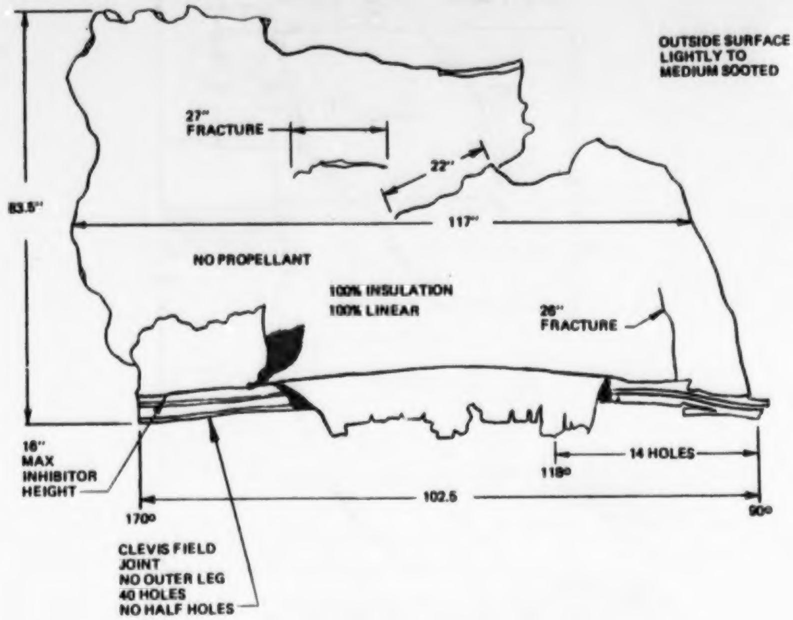
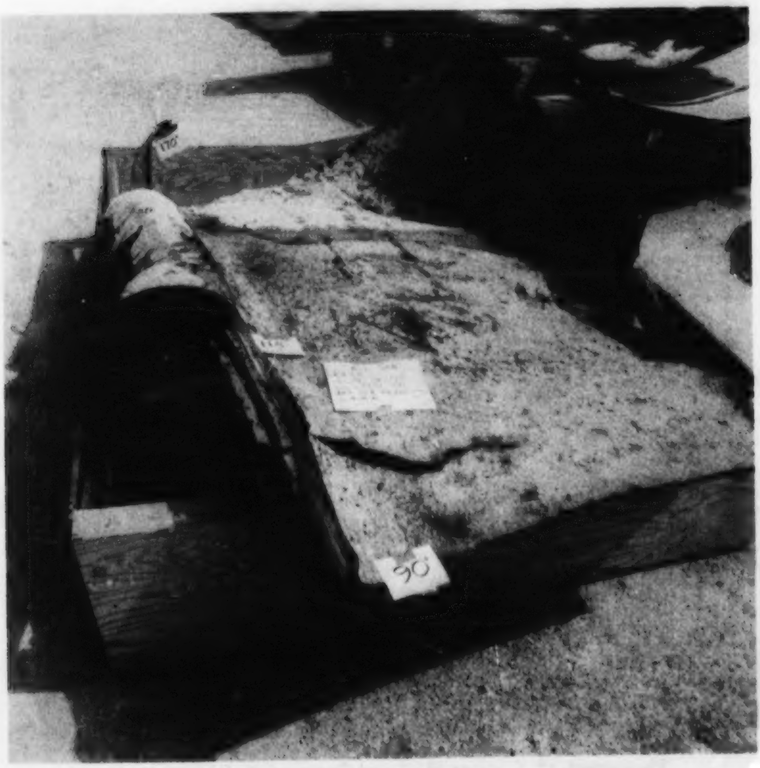

OUTSIDE SURFACE
LIGHTLY TO
MEDIUM SOOTED
27"
FRACTURE
22"
83.5"
117"
NO PROPELLANT
100% INSULATION
100% LINEAR
26"
FRACTURE
16"
MAX
INHIBITOR
HEIGHT
14 HOLES
118°
102.5
170°
90°
CLEVIS FIELD
JOINT
NO OUTER LEG
40 HOLES
NO HALF HOLES

Figure 60. Contact 433, Aft Center Segment, Forward Cylinder



Photograph 39. Contact 433, Aft Center Segment, Forward Cylinder

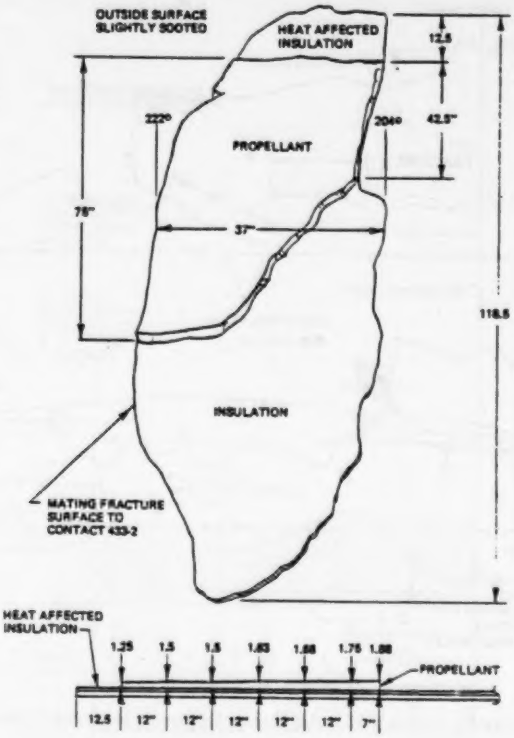
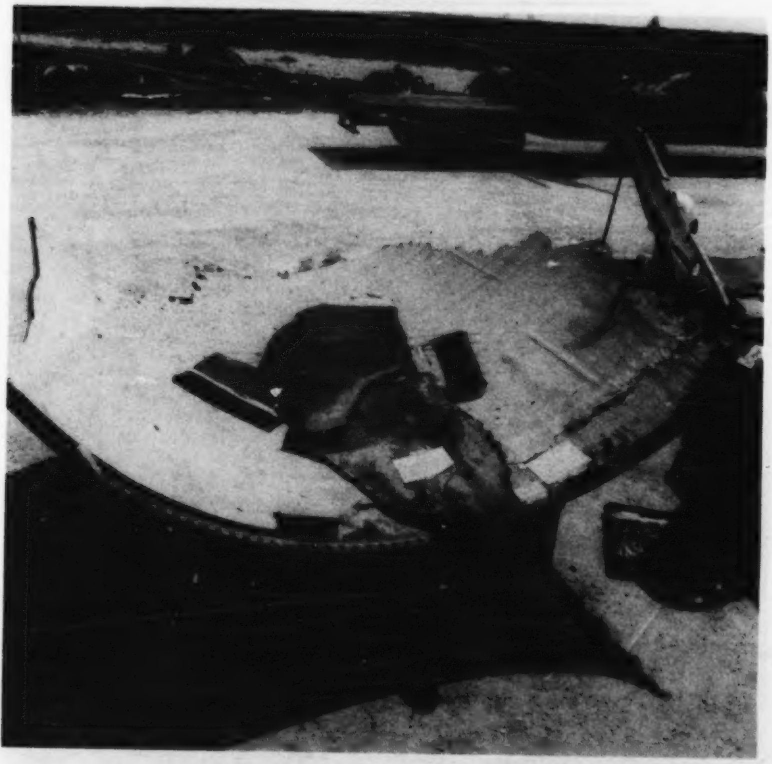

OUTSIDE SURFACE SLIGHTLY SOOTED
HEAT AFFECTED INSULATION
12.5
222°
204°
42.5"
PROPELLANT
78"
37"
118.5
INSULATION
MATING FRACTURE SURFACE TO CONTACT 433-2
HEAT AFFECTED INSULATION
1.25
1.5
1.5
1.83
1.88
1.75
1.88
PROPELLANT
12.5
12"
12"
12"
12"
12"
7"

Figure 61. Contact 433-1, RH Aft Center Segment, Aft Cylinder



Photograph 40. Contact 433-1 and Contact 635, RH Aft Center Segment, Aft Cylinder and LH Forward Segment, Forward Cylinder

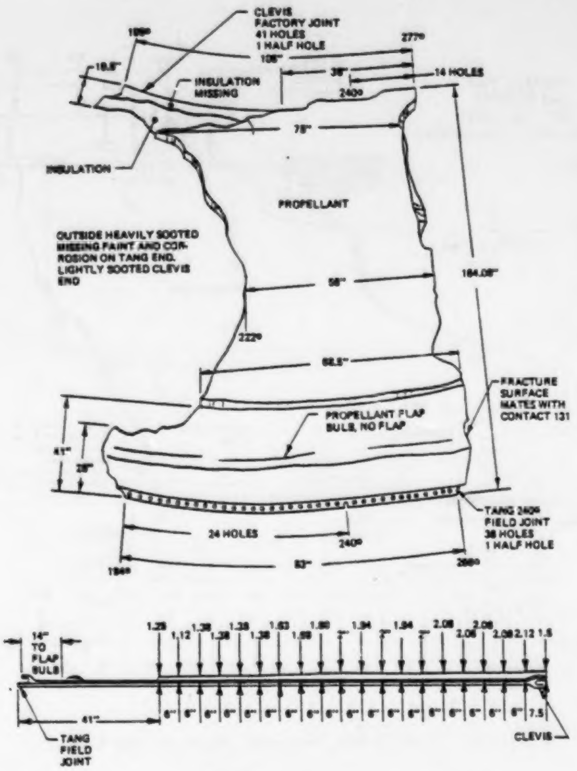
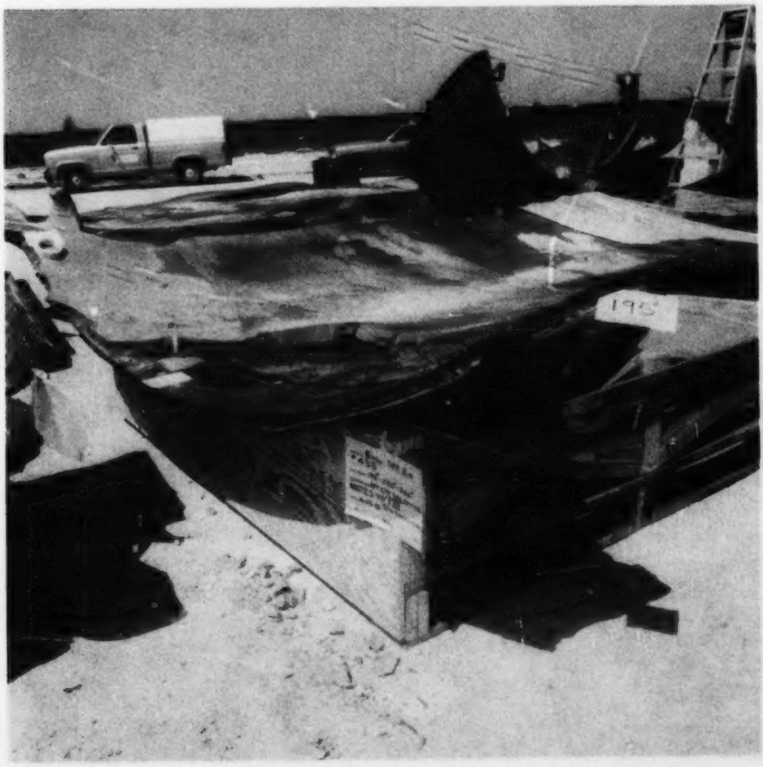

CLEVIS
FACTORY JOINT
41 HOLES
1 HALF HOLE
189°
277°
19.5"
106"
38"
14 HOLES
INSULATION
MISSING
240°
78"
INSULATION
PROPELLANT
OUTSIDE HEAVILY SOOTED
MISSING PAINT AND COR-
ROSION ON TANG END.
LIGHTLY SOOTED CLEVIS
END
58"
184.08"
222°
68.5"
FRACTURE
SURFACE
MATES WITH
CONTACT 131
PROPELLANT FLAP
BULB, NO FLAP
41"
28"
TANG 240°
FIELD JOINT
38 HOLES
1 HALF HOLE
24 HOLES
240°
184°
83"
288°
14"
TO
FLAP
BULB
1.25
1.12
1.38
1.38
1.38
1.38
1.63
1.59
1.80
2"
1.94
2"
1.94
2"
2.08
2.06
2.08
2.08
2.12
1.5
6"
7.5
41"
TANG
FIELD
JOINT
CLEVIS

Figure 62. Contact 433-2, RH Aft Center Segment, Aft Cylinder



Photograph 41. Contact 433-2, RH Aft Center Segment, Aft Cylinder

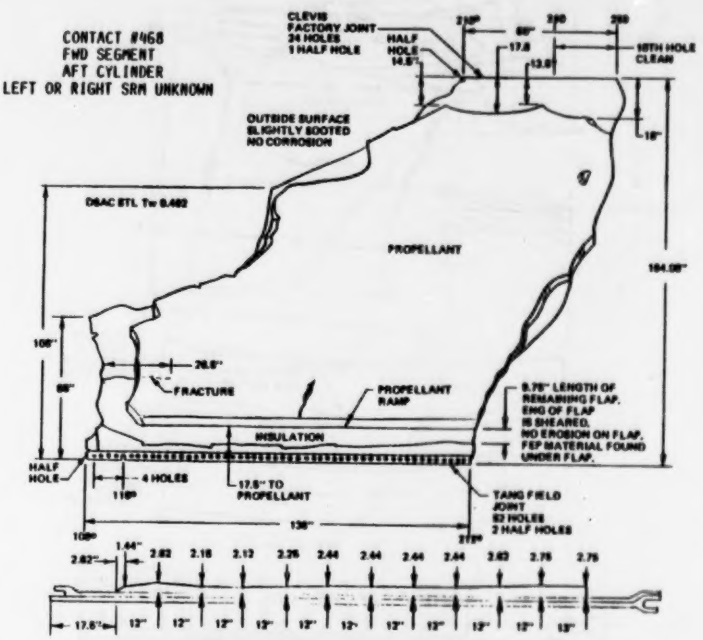

CONTACT #468
FWD SEGMENT
AFT CYLINDER
LEFT OR RIGHT SRM UNKNOWN
CLEVIS
FACTORY JOINT
24 HOLES
1 HALF HOLE
HALF
HOLE
14.8"
218°
60"
280
289
17.8
13.8"
19TH HOLE
CLEAN
18"
OUTSIDE SURFACE
SLIGHTLY SOOTED
NO CORROSION
DSAC STL Tw 0.482
PROPELLANT
184.08"
108"
88"
28.8"
FRACTURE
PROPELLANT
RAMP
9.75" LENGTH OF
REMAINING FLAP.
END OF FLAP
IS SHEARED.
NO EROSION ON FLAP.
FEP MATERIAL FOUND
UNDER FLAP.
INSULATION
HALF
HOLE
4 HOLES
118°
17.5" TO
PROPELLANT
TANG FIELD
JOINT
52 HOLES
2 HALF HOLES
138"
108°
272°
1.44"
2.82"
2.82
2.18
2.12
2.26
2.44
2.44
2.44
2.44
2.82
2.76
2.76
17.8"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"

Figure 63. Contact 468, Forward Segment, Aft Cylinder

Photograph 42. Contact 468, Forward Segment, Aft Cylinder

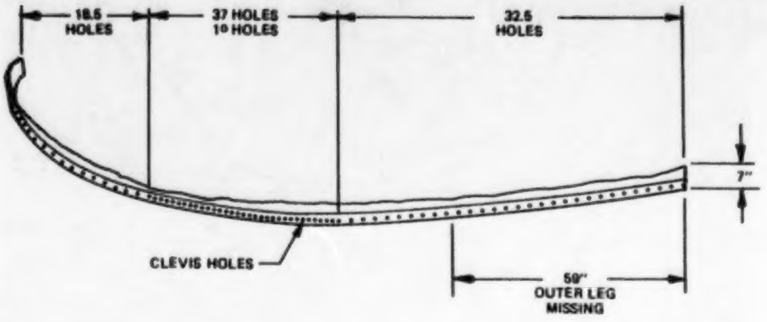
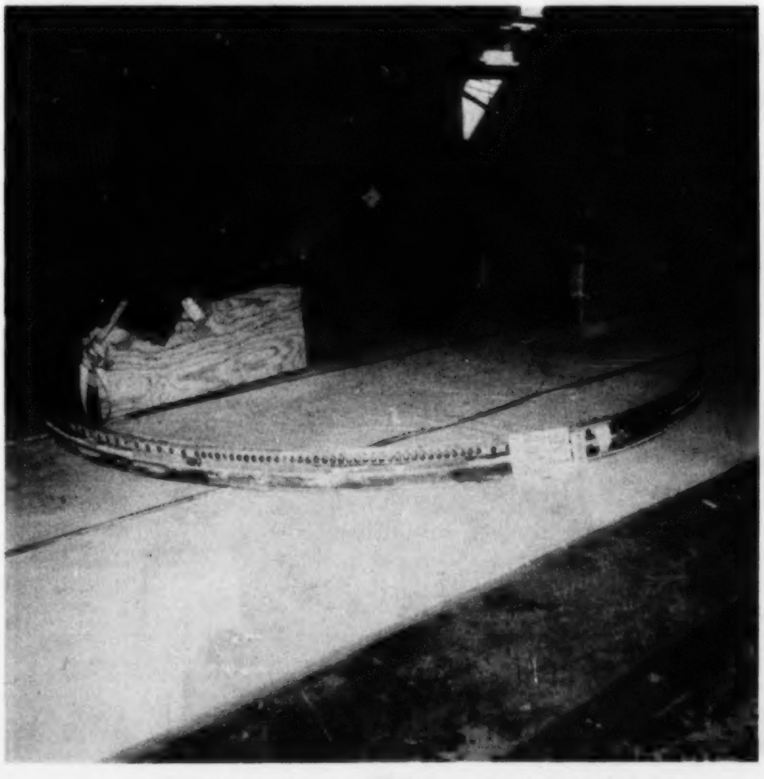

18.5
HOLES
37 HOLES
1° HOLES
32.5
HOLES
7"
CLEVIS HOLES
59"
OUTER LEG
MISSING

Figure 64. Contact 487, Forward Skirt Clevis Joint



Photograph 43. Contact 487, Forward Skirt Clevis Joint

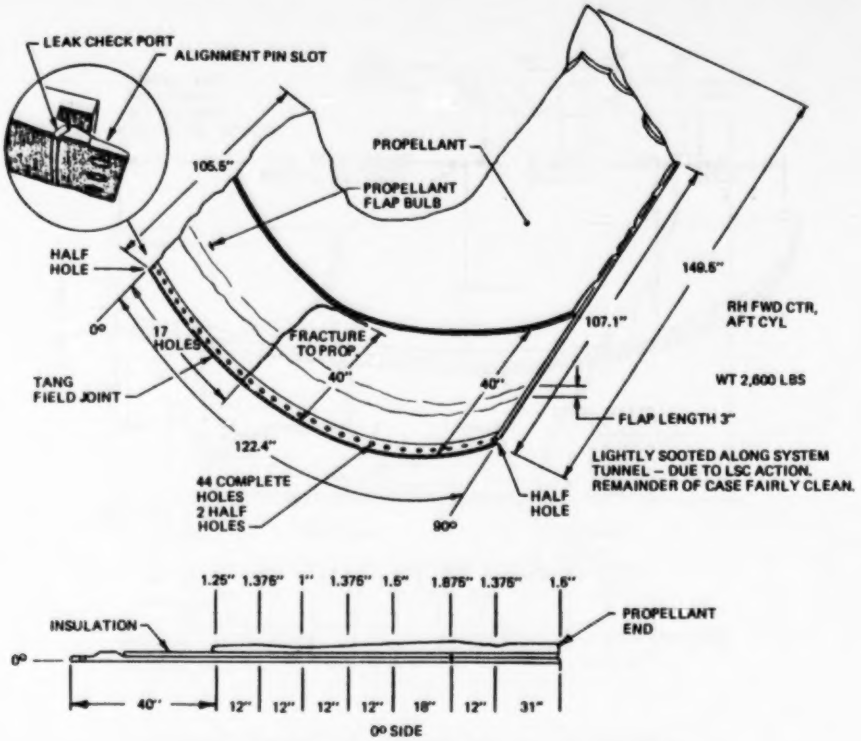
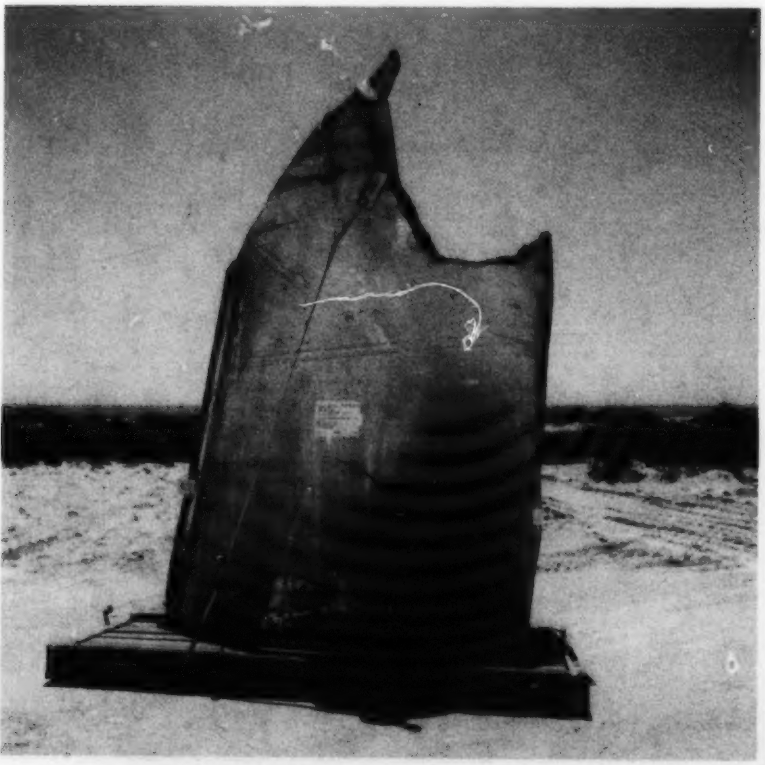
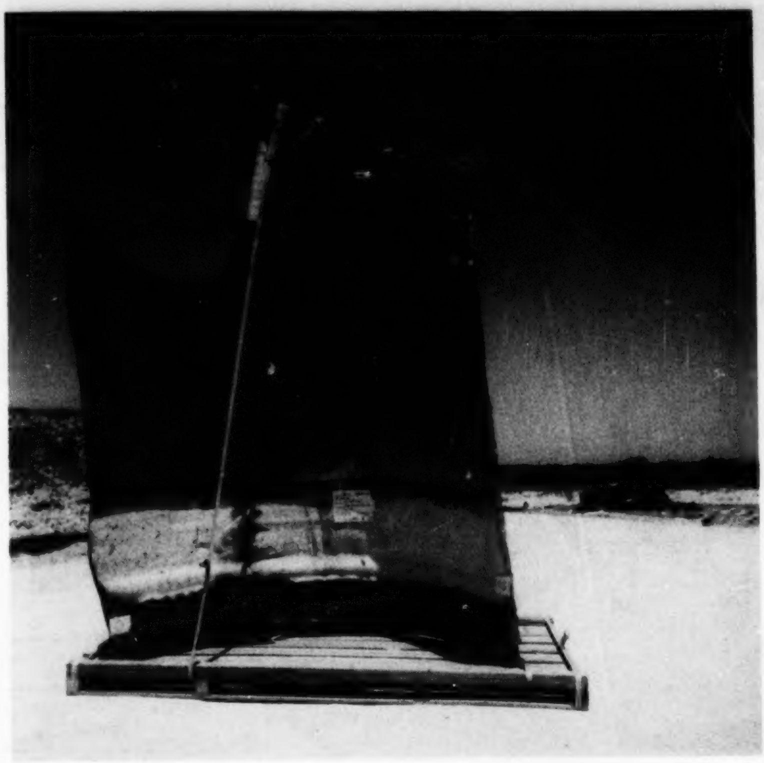

LEAK CHECK PORT
ALIGNMENT PIN SLOT
105.5"
PROPELLANT
PROPELLANT FLAP BULB
HALF HOLE
0°
17 HOLES
FRACTURE TO PROP
40"
40"
TANG FIELD JOINT
122.4"
44 COMPLETE HOLES 2 HALF HOLES
90°
HALF HOLE
107.1"
149.5"
RH FWD CTR, AFT CYL
WT 2,600 LBS
FLAP LENGTH 3"
LIGHTLY SOOTED ALONG SYSTEM TUNNEL – DUE TO LSC ACTION. REMAINDER OF CASE FAIRLY CLEAN.
1.25" 1.375" 1" 1.375" 1.5" 1.875" 1.375" 1.5"
INSULATION
PROPELLANT END
0°
40" 12" 12" 12" 12" 18" 12" 31"
0° SIDE

Figure 65. Contact 502, Forward Center Segment, Aft Cylinder



Photograph 44. Contact 502, Forward Center Segment, Aft Cylinder Outside View



Photograph 45. Contact 502, Forward Center Segment, Aft Cylinder, Inside View

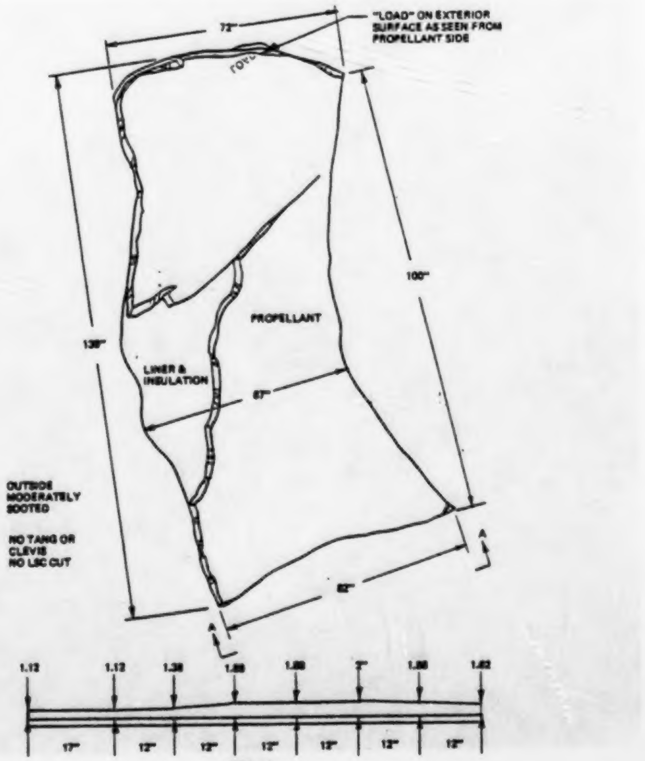
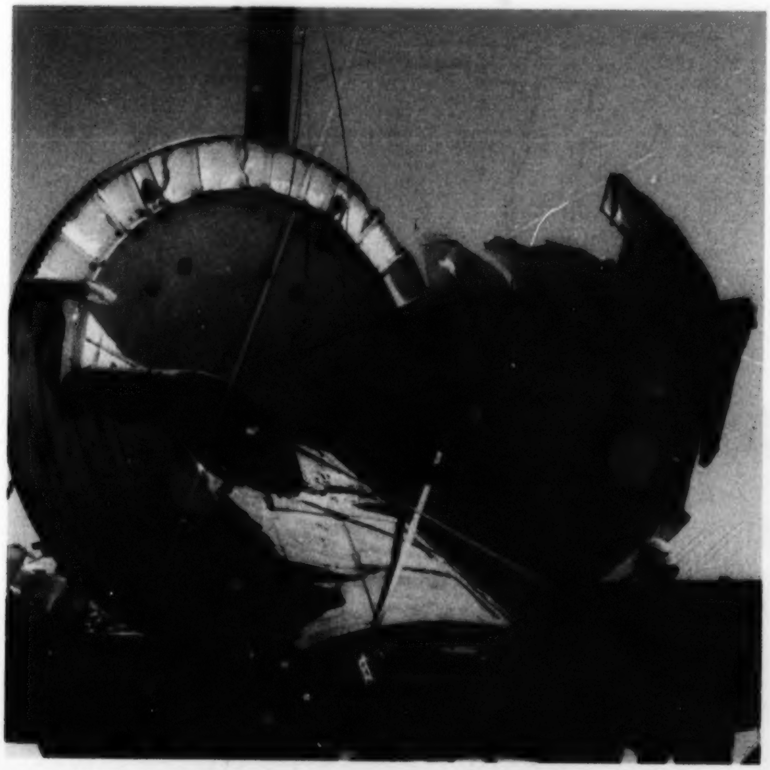

72"
"LOAD" ON EXTERIOR SURFACE AS SEEN FROM PROPELLANT SIDE
LOAD
100"
138"
PROPELLANT
LINER & INSULATION
67"
OUTSIDE MODERATELY SOOTED
NO TANG OR CLEVIS NO LSC CUT
82"
A
A
1.12
1.12
1.38
1.88
1.88
2"
1.88
1.82
17"
12"
12"
12"
12"
12"
12"
VIEW A-A

Figure 66. Contact 524, Case Cylinder Segment, Fragment

Photograph 46. Contact 524, Case Cylinder Segment Fragment



Photograph 47. Contact 538, RH Forward Skirt

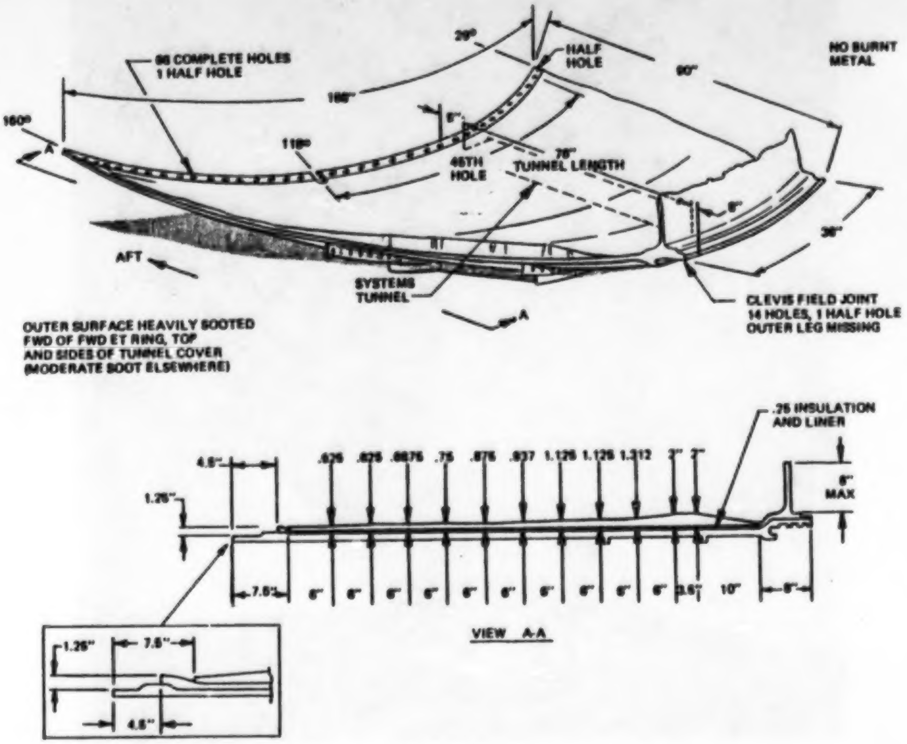
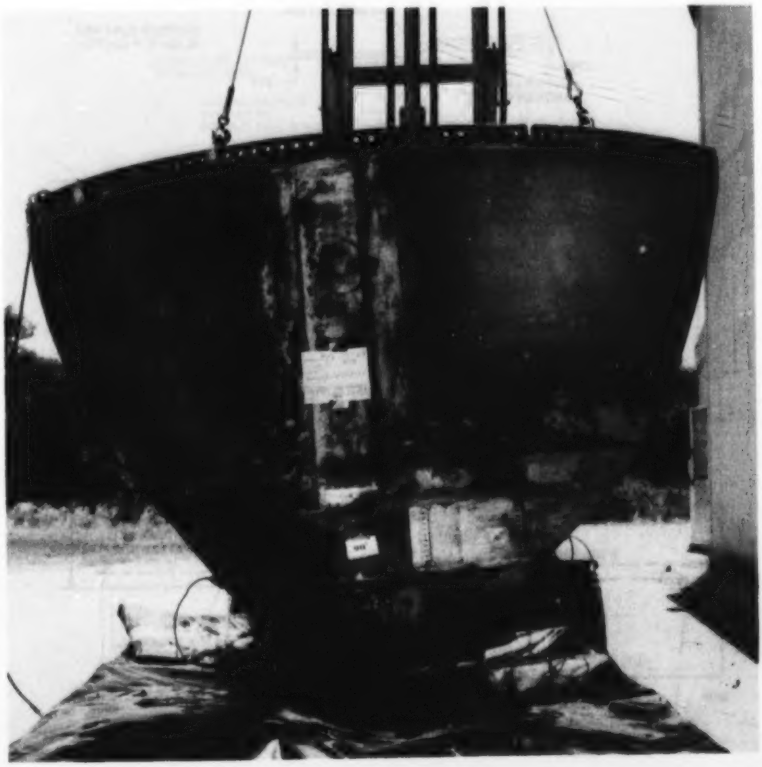
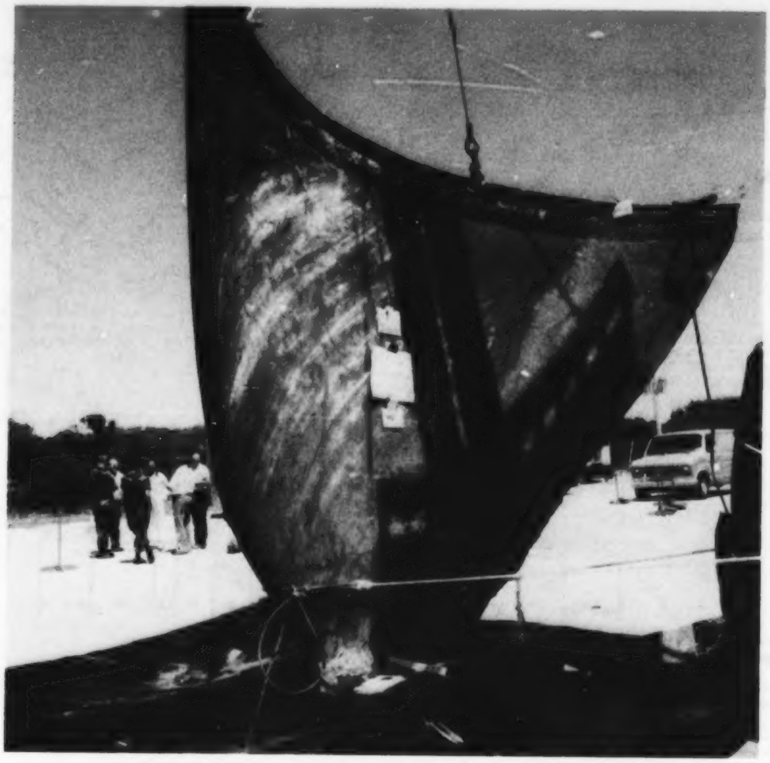

29°
HALF HOLE
NO BURNT METAL
98 COMPLETE HOLES 1 HALF HOLE
90"
166"
160°
5"
A
118°
76" TUNNEL LENGTH
46TH HOLE
6"
36"
AFT
SYSTEMS TUNNEL
CLEVIS FIELD JOINT 14 HOLES, 1 HALF HOLE OUTER LEG MISSING
A
OUTER SURFACE HEAVILY SOOTED FWD OF FWD ET RING, TOP AND SIDES OF TUNNEL COVER (MODERATE SOOT ELSEWHERE)
.25 INSULATION AND LINER
4.5"
.625 .625 .6875 .75 .875 .937 1.125 1.125 1.312 2" 2"
1.25"
6" MAX
7.5"
6" 6" 6" 6" 6" 6" 6" 6" 6" 6"
3.5"
10"
6"
VIEW A-A
1.25"
7.5"
4.5"

Figure 67. Contact 579, RH Aft Segment Attach Segment

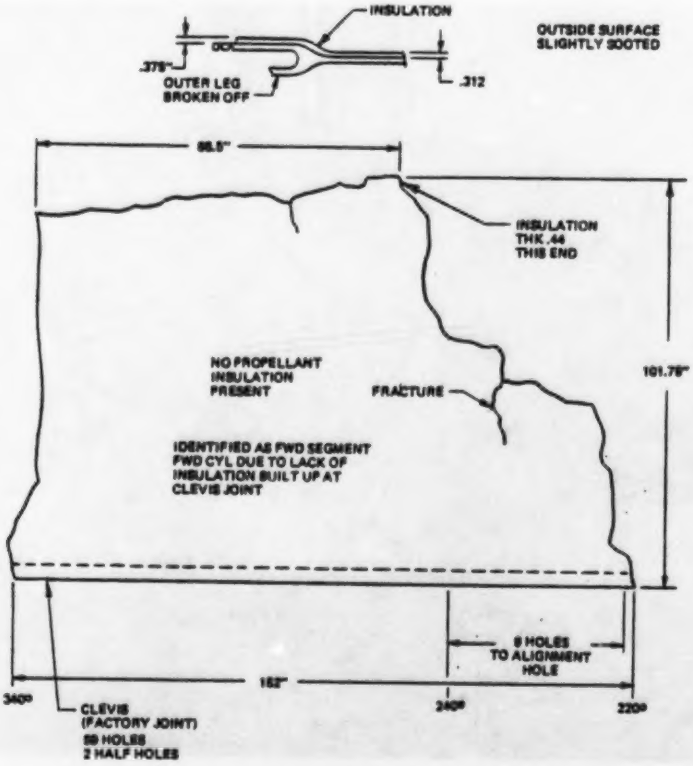


Photograph 48. Contact 579, RH Aft Segment, Attach Segment, Outside View



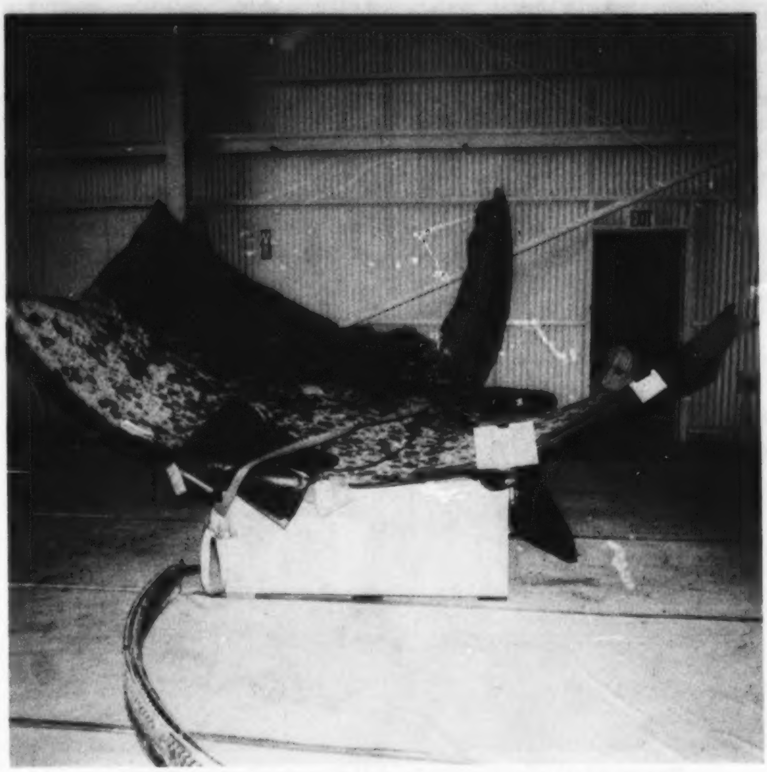
Photograph 49. Contact 579, RH Aft Segment, Attach Segment, Inside View

---



INSULATION
OUTSIDE SURFACE SLIGHTLY SOOTED
.375"
OUTER LEG BROKEN OFF
.312
88.5"
INSULATION THK .44 THIS END
101.75"
NO PROPELLANT INSULATION PRESENT
FRACTURE
IDENTIFIED AS FWD SEGMENT FWD CYL DUE TO LACK OF INSULATION BUILT UP AT CLEVIS JOINT
9 HOLES TO ALIGNMENT HOLE
152"
340°
240°
220°
CLEVIS (FACTORY JOINT)
59 HOLES
2 HALF HOLES

Figure 68. Contact 605, Forward Segment, Forward Cylinder



Photograph 50. Contact 605, Forward Segment, Forward Cylinder

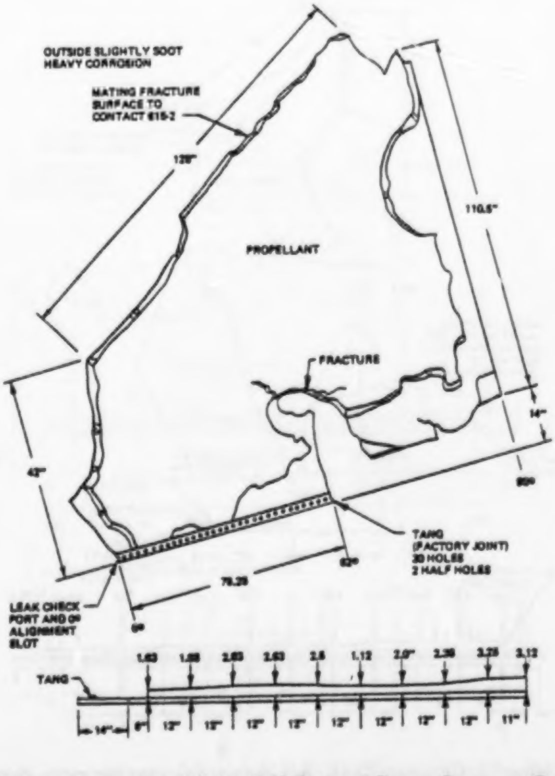
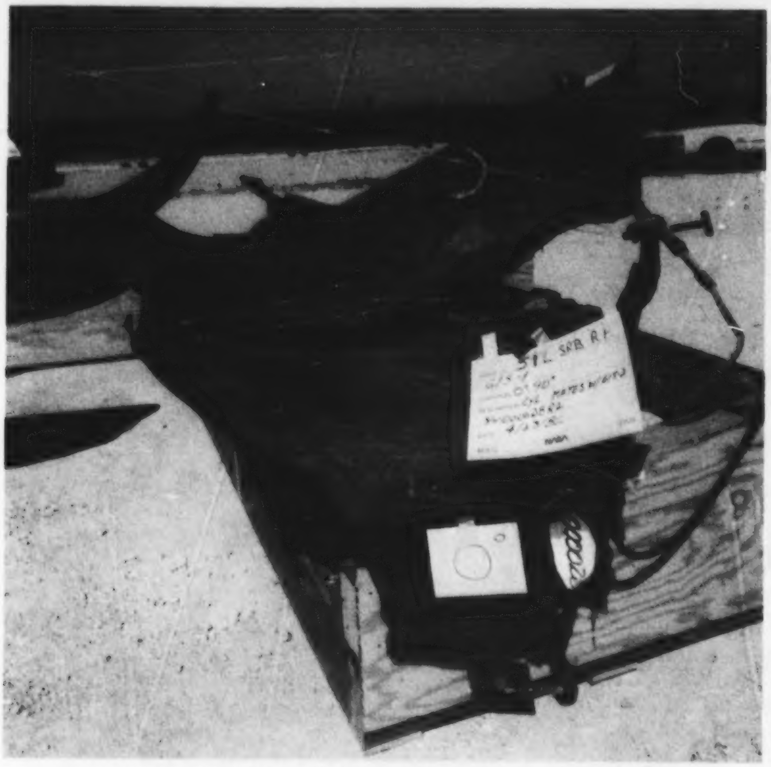

OUTSIDE SLIGHTLY SOOT
HEAVY CORROSION
MATING FRACTURE SURFACE TO CONTACT 615-2
128"
110.5"
PROPELLANT
FRACTURE
14"
90°
42"
TANG (FACTORY JOINT) 30 HOLES 2 HALF HOLES
82°
78.25
LEAK CHECK PORT AND 0° ALIGNMENT SLOT
0°
1.63
1.88
2.63
2.63
2.5
1.12
2.0"
2.38
3.25
3.12
TANG
14"
6"
12"
12"
12"
12"
12"
12"
12"
12"
11"

Figure 69. Contact 615-1A, RH Forward Center Segment, Forward Cylinder


51L SRB R.H.
NASA

Photograph 51. Contact 615-1A, RH Forward Center Segment, Forward Cylinder

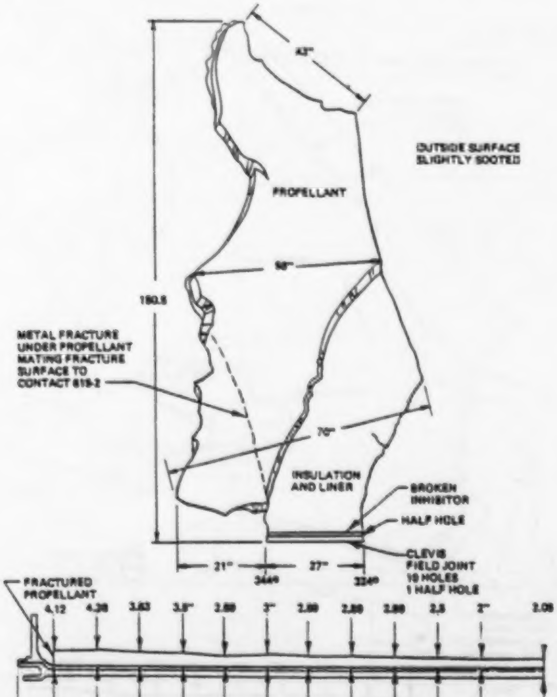
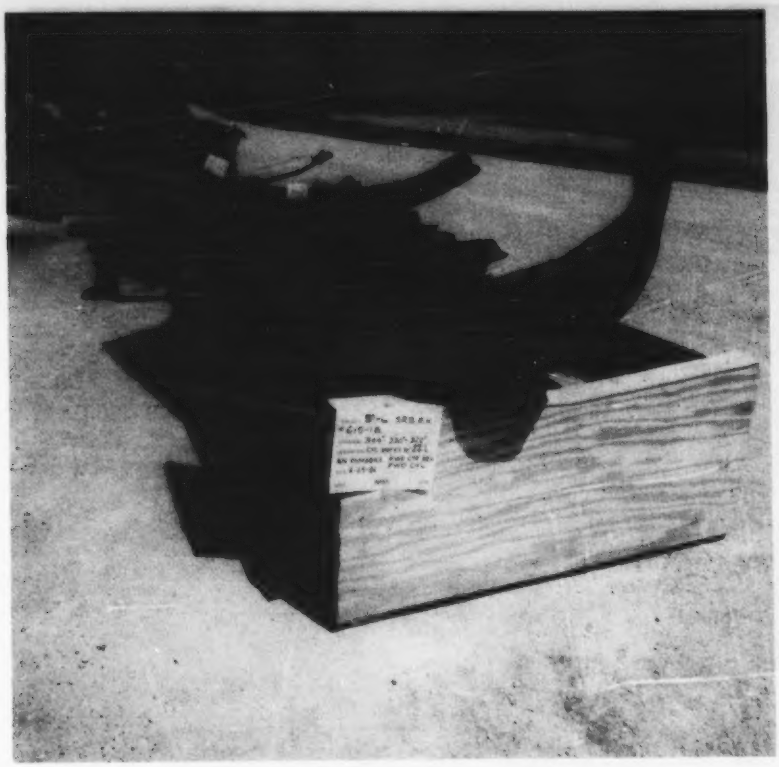

42"
OUTSIDE SURFACE SLIGHTLY SOOTED
PROPELLANT
58"
150.5
METAL FRACTURE UNDER PROPELLANT MATING FRACTURE SURFACE TO CONTACT 615-2
70"
INSULATION AND LINER
BROKEN INHIBITOR
HALF HOLE
CLEVIS FIELD JOINT 10 HOLES 1 HALF HOLE
21"
27"
344°
324°
FRACTURED PROPELLANT
4.12
4.28
3.63
3.8"
2.80
3"
2.80
2.80
2.80
2.5
2"
2.08
10"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
18"

Figure 70. Contact 615-1B, RH Forward Center Segment, Forward Cylinder



Photograph 52. Contact 615-1B, RH Forward Center Segment, Forward Cylinder

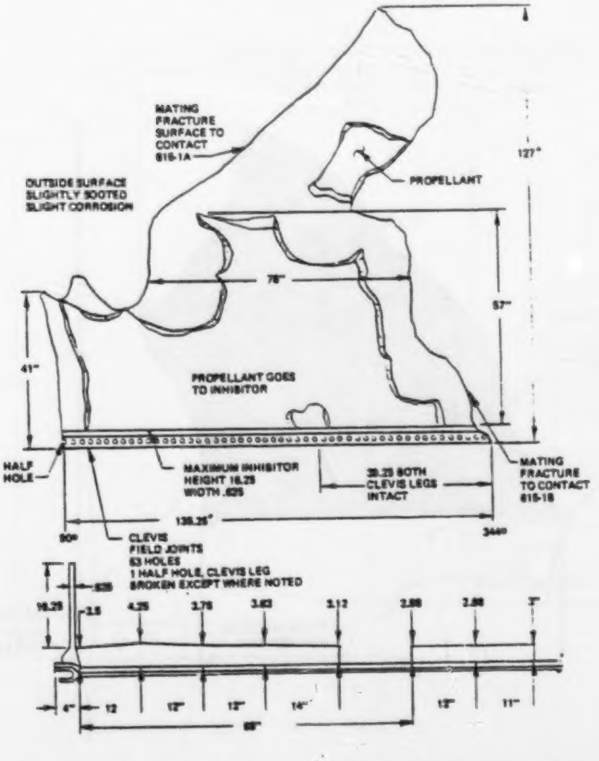
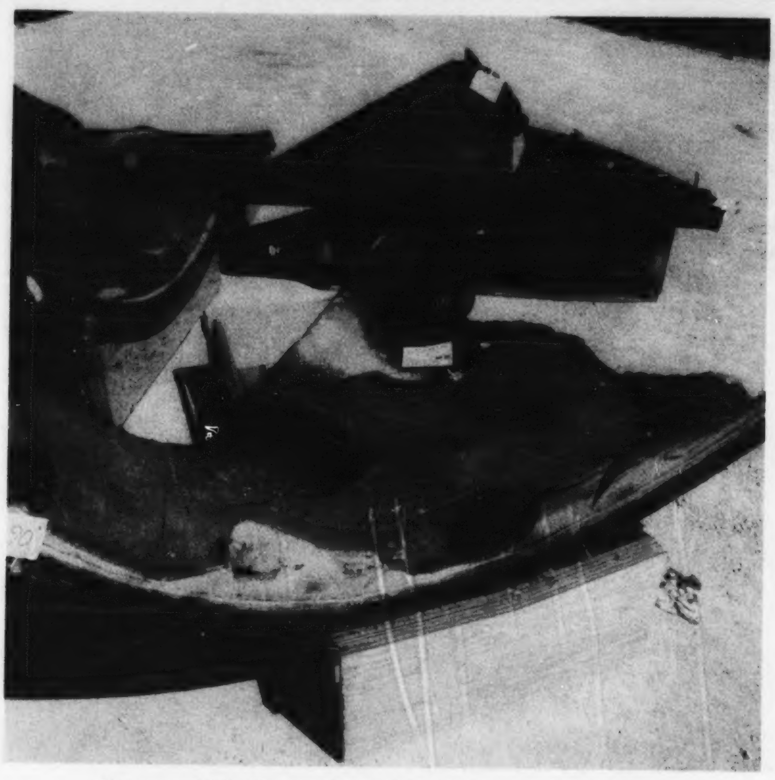

MATING FRACTURE SURFACE TO CONTACT 615-1A
127"
PROPELLANT
OUTSIDE SURFACE SLIGHTLY SOOTED SLIGHT CORROSION
78"
57"
41"
PROPELLANT GOES TO INHIBITOR
HALF HOLE
MAXIMUM INHIBITOR HEIGHT 16.25 WIDTH .625
39.25 BOTH CLEVIS LEGS INTACT
MATING FRACTURE TO CONTACT 615-1B
138.25"
90°
344°
CLEVIS FIELD JOINTS 63 HOLES 1 HALF HOLE, CLEVIS LEG BROKEN EXCEPT WHERE NOTED
.625
16.25
3.5
4.25
3.75
3.63
3.12
2.88
2.88
3"
4"
12
12"
12"
14"
12"
11"
68"

Figure 71. Contact 615-2, RH Forward Center Segment, Forward Cylinder



Photograph 53. Contact 615-2, RH Aft Segment, Aft Stiffener

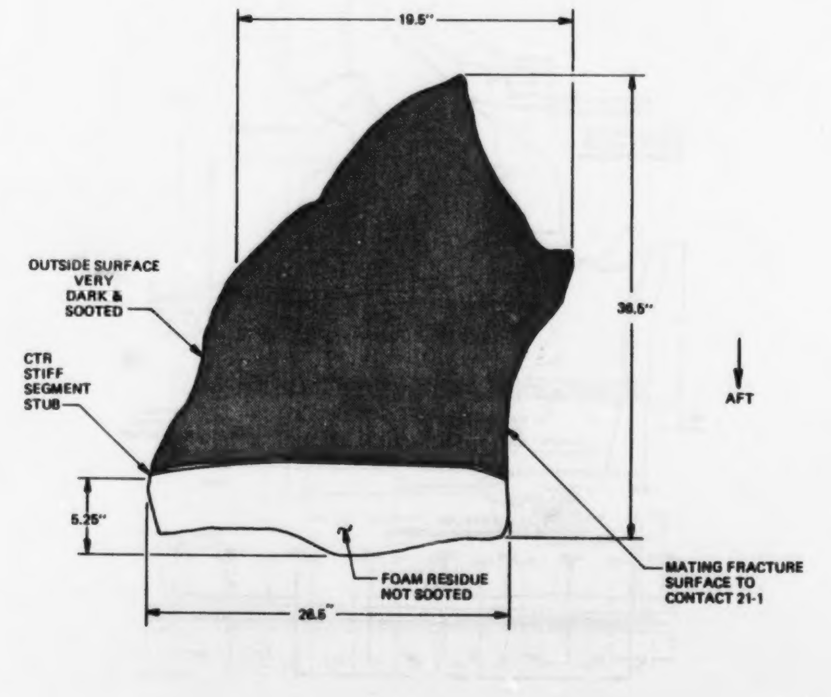

19.5"
OUTSIDE SURFACE VERY DARK & SOOTED
CTR STIFF SEGMENT STUB
36.5"
AFT
5.25"
FOAM RESIDUE NOT SOOTED
26.5"
MATING FRACTURE SURFACE TO CONTACT 21-1

Figure 72. Contact 615-3. RH Aft Segment, Aft Stiffener

Photograph 66. Contact 5126-1, Forward Segment, Aft Cylinder

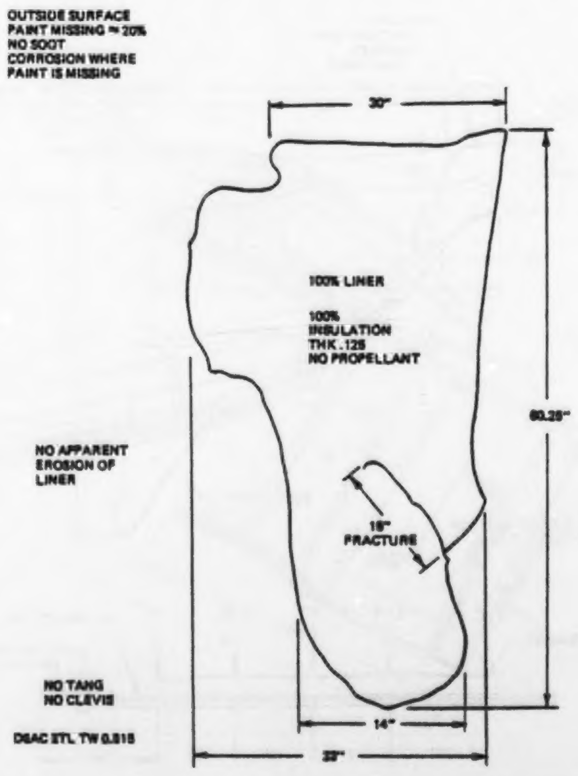
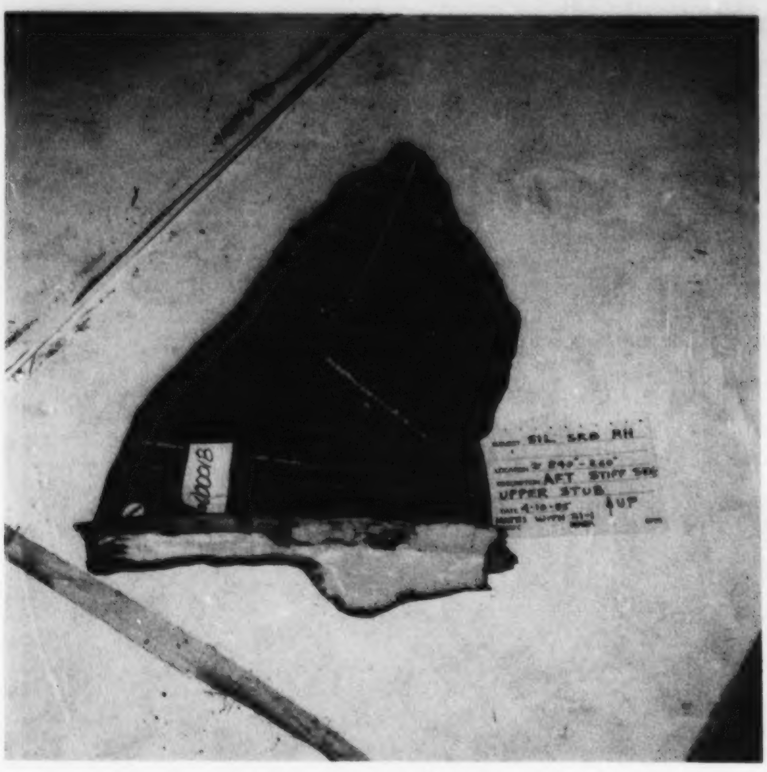

OUTSIDE SURFACE PAINT MISSING ≈ 20% NO SOOT CORROSION WHERE PAINT IS MISSING
30"
100% LINER
100% INSULATION THK .125 NO PROPELLANT
60.25"
NO APPARENT EROSION OF LINER
18" FRACTURE
NO TANG NO CLEVIS
D6AC STL TW 0.515
14"
22"

Figure 85. Contact 5126-2, Forward Segment, Aft Cylinder


51L SRB RH
240°-260°
AFT STIFF SEG
UPPER STUB
UP

Photograph 54. Contact 615-3, RH Aft Segment, Aft Stiffener

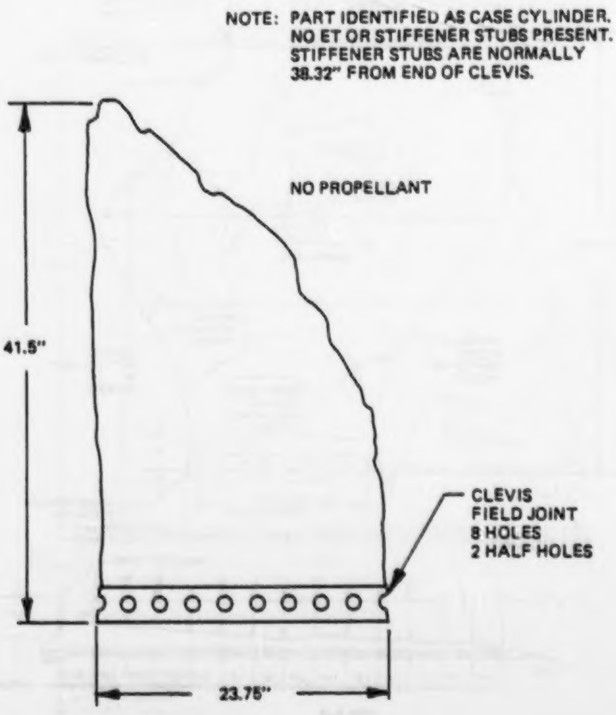

NOTE: PART IDENTIFIED AS CASE CYLINDER. NO ET OR STIFFENER STUBS PRESENT. STIFFENER STUBS ARE NORMALLY 38.32" FROM END OF CLEVIS.
NO PROPELLANT
41.5"
CLEVIS
FIELD JOINT
8 HOLES
2 HALF HOLES
23.75"

Figure 73. Contact 615-4, Case Cylinder Fragment

Photograph 67. Contact 5126-2, Forward Segment, Case Cylinder

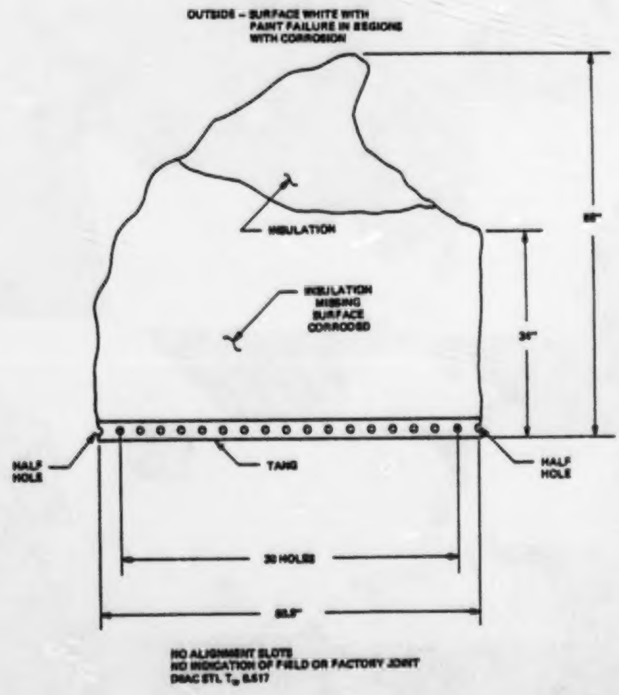
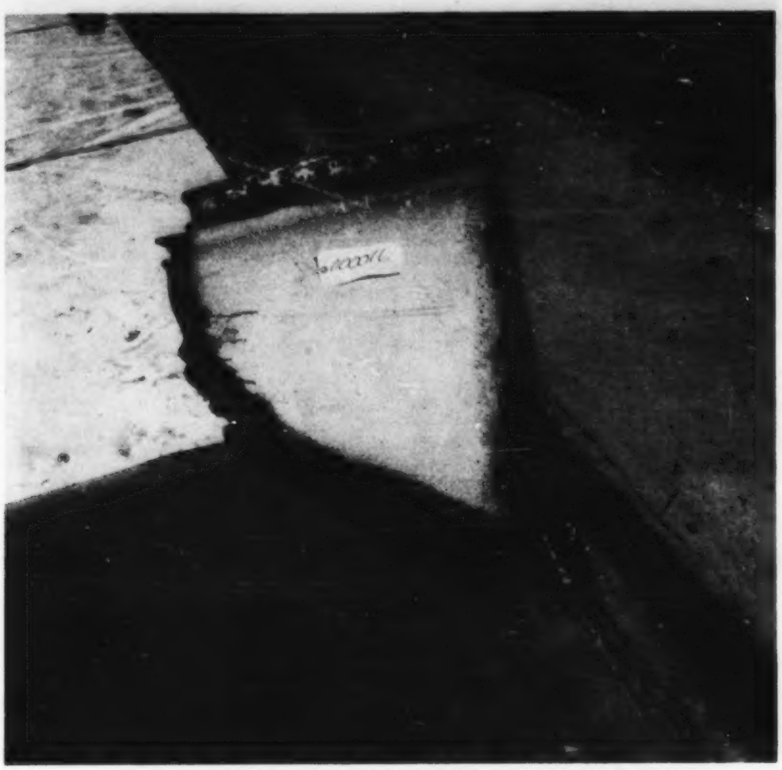
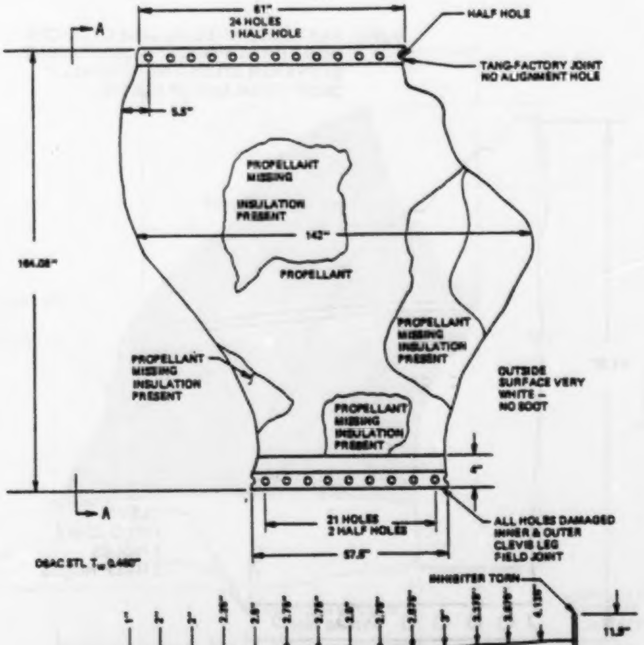

NO PROPELLANT
OUTSIDE – SURFACE WHITE WITH PAINT FAILURE IN REGIONS WITH CORROSION
INSULATION
INSULATION MISSING SURFACE CORRODED
34"
HALF HOLE
TANG
HALF HOLE
30 HOLES
NO ALIGNMENT SLOTS
NO INDICATION OF FIELD OR FACTORY JOINT
D6AC STL T_w 0.517

Figure 86. Contact 5128, Forward Segment, Case Cylinder

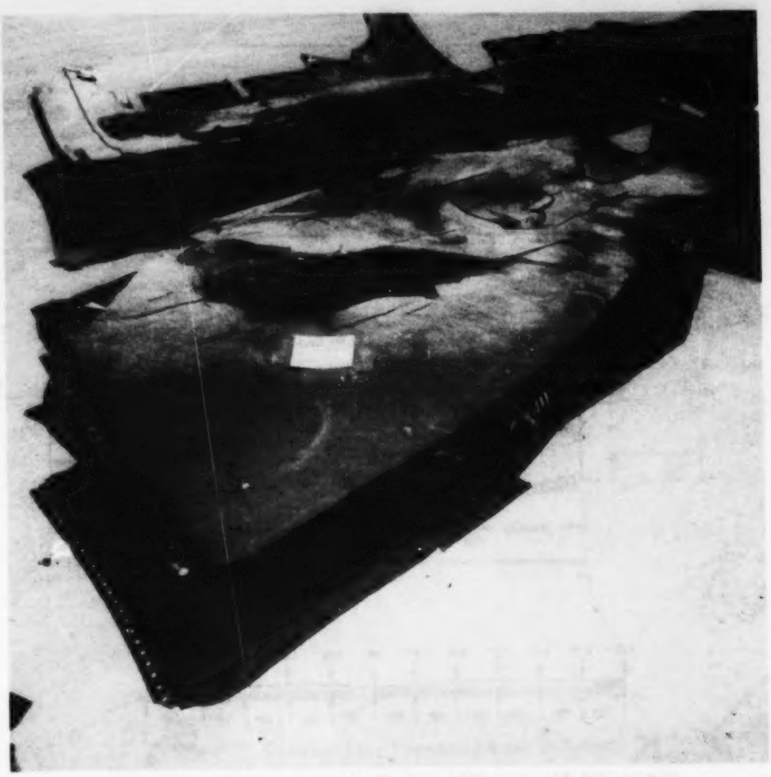


Photograph 55. Contact 615-4, Case Cylinder Segment



61"
24 HOLES
1 HALF HOLE
HALF HOLE
A
TANG-FACTORY JOINT
NO ALIGNMENT HOLE
5.5"
PROPELLANT
MISSING
INSULATION
PRESENT
142"
164.08"
PROPELLANT
PROPELLANT
MISSING
INSULATION
PRESENT
PROPELLANT
MISSING
INSULATION
PRESENT
OUTSIDE
SURFACE VERY
WHITE –
NO SOOT
PROPELLANT
MISSING
INSULATION
PRESENT
6"
A
21 HOLES
2 HALF HOLES
ALL HOLES DAMAGED
INNER & OUTER
CLEVIS LEG
FIELD JOINT
57.5"
D6AC STL. T_m 0.460"
INHIBITER TORN
1"
2"
2"
2.75"
2.5"
2.75"
2.75"
2.5"
2.75"
2.875"
3"
3.375"
3.875"
4.125"
11.5"
TANG
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
6"
DATUM
VIEW A–A

Figure 74. Contact 631, Forward Center or Aft Center Segment Forward Cylinder



Photograph 56. Contact 631, Forward Center or Aft Center Segment, Forward Cylinder

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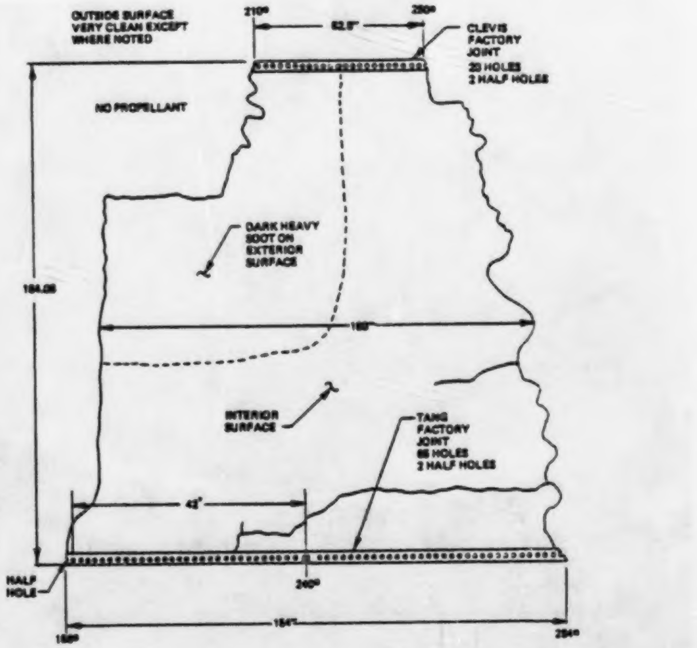

OUTSIDE SURFACE
VERY CLEAN EXCEPT
WHERE NOTED
210°
52.5"
250°
CLEVIS
FACTORY
JOINT
20 HOLES
2 HALF HOLES
NO PROPELLANT
DARK HEAVY
SOOT ON
EXTERIOR
SURFACE
184.06
180"
INTERIOR
SURFACE
TANG
FACTORY
JOINT
65 HOLES
2 HALF HOLES
42"
HALF
HOLE
240°
184"
158°
294°

IDENTIFIED AS LEFT-HAND
FROM TANG THICKNESS
(0.763"/0.762") MATED
MATCHING ORIGINAL HARD-
WARE THICKNESS (0.762")

Figure 75. Contact 635, LH Forward Segment, Forward Cylinder

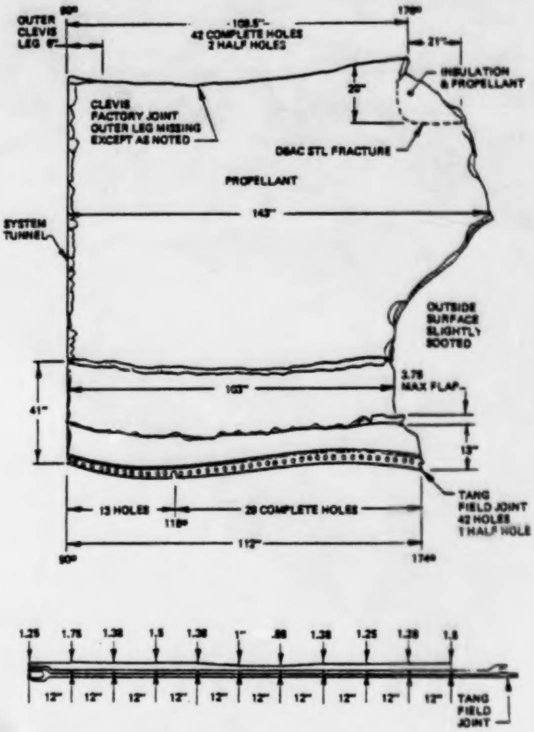
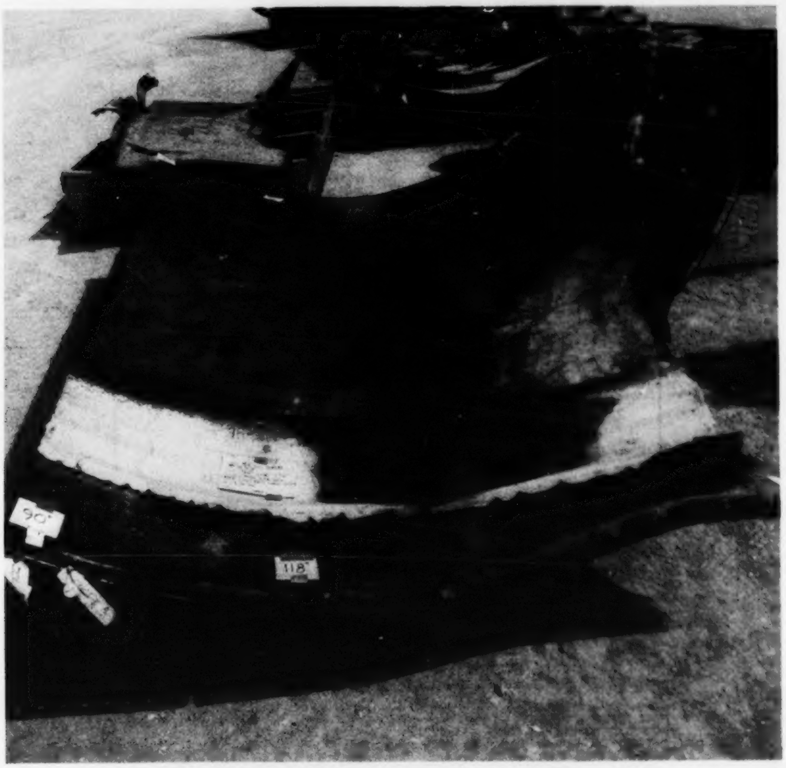

90°
OUTER CLEVIS LEG 6"
108.5"
42 COMPLETE HOLES
2 HALF HOLES
176°
21"
INSULATION & PROPELLANT
20"
CLEVIS FACTORY JOINT OUTER LEG MISSING EXCEPT AS NOTED
D6AC STL FRACTURE
PROPELLANT
143"
SYSTEM TUNNEL
OUTSIDE SURFACE SLIGHTLY SOOTED
103"
3.75 MAX FLAP
41"
13"
13 HOLES
118°
29 COMPLETE HOLES
TANG FIELD JOINT 42 HOLES 1 HALF HOLE
112"
90°
174°
1.25
1.75
1.38
1.5
1.38
1"
.88
1.38
1.25
1.38
1.5
12"
12"
12"
12"
12"
12"
12"
12"
12"
12"
TANG FIELD JOINT

Figure 76. Contact 699, RH Forward Center Segment, Aft Cylinder



Photograph 57. Contact 699, RH Forward Center Segment, Aft Cylinder

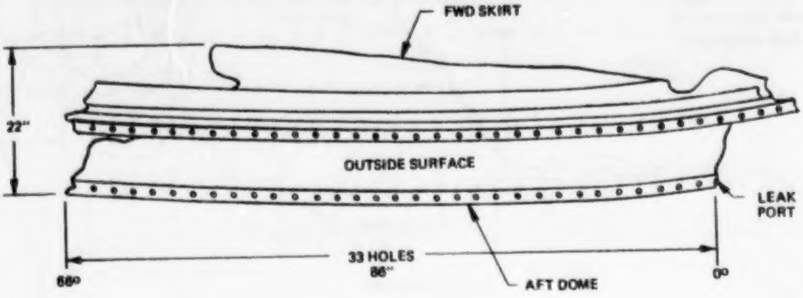
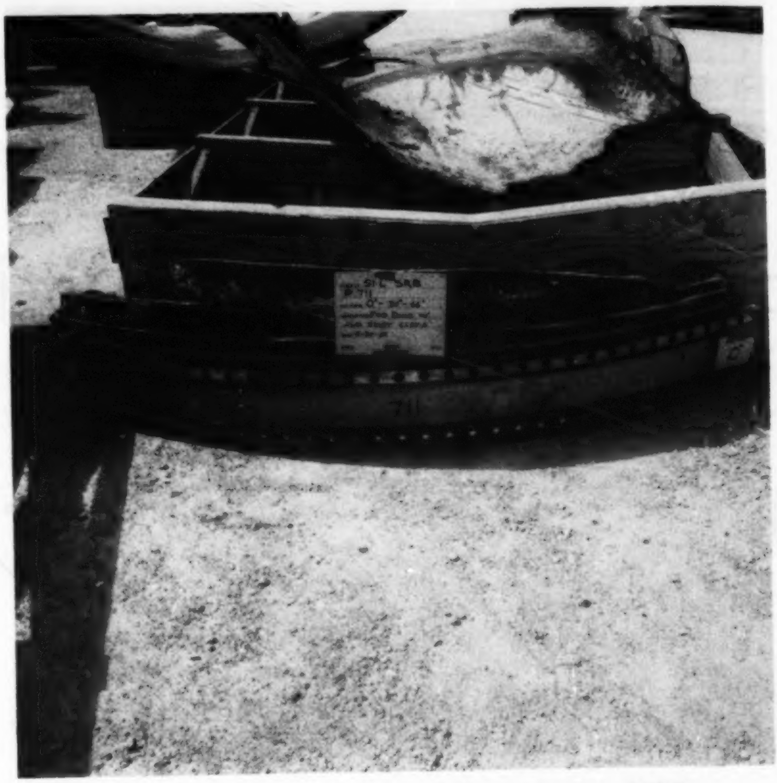

FWD SKIRT
22"
OUTSIDE SURFACE
LEAK PORT
33 HOLES
86"
66°
AFT DOME
0°

Figure 77. Contact 711, Forward Dome Fragment



Photograph 58. Contact 711, Forward Dome with Forward Skirt Clevis

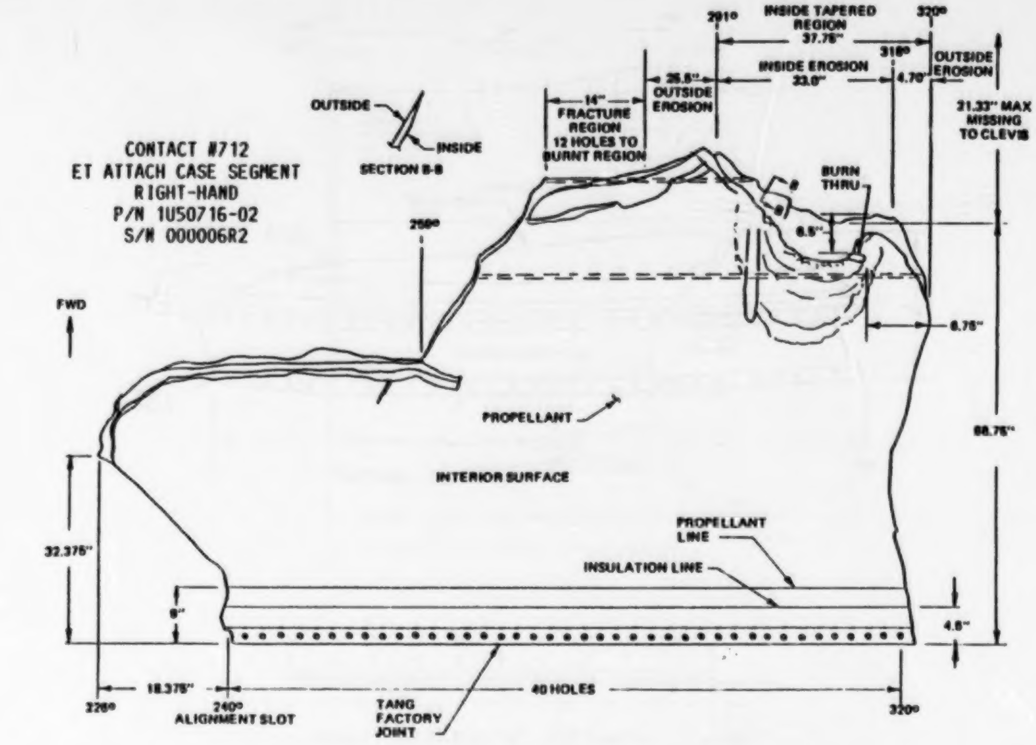

CONTACT #712
ET ATTACH CASE SEGMENT
RIGHT-HAND
P/N 1U50716-02
S/N 000006R2
OUTSIDE
INSIDE
SECTION B-B
291°
INSIDE TAPERED REGION 37.75"
320°
318°
INSIDE EROSION 23.0"
4.70"
OUTSIDE EROSION
25.5" OUTSIDE EROSION
14" FRACTURE REGION 12 HOLES TO BURNT REGION
21.33" MAX MISSING TO CLEVIS
BURN THRU
6.5"
6.75"
250°
FWD
PROPELLANT
INTERIOR SURFACE
66.75"
PROPELLANT LINE
INSULATION LINE
32.375"
6"
4.8"
18.375"
40 HOLES
220°
240° ALIGNMENT SLOT
TANG FACTORY JOINT
320°

Figure 78. Contact 712, RH Aft Segment Attach Segment, Interior Surface

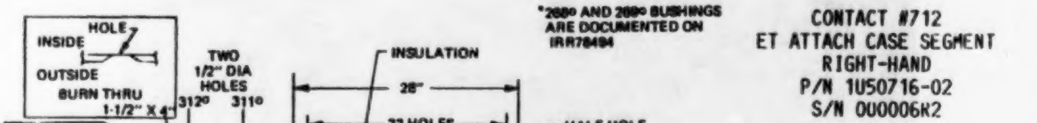

*268° AND 269° BUSHINGS ARE DOCUMENTED ON IRR78494
CONTACT #712
ET ATTACH CASE SEGMENT
RIGHT-HAND
P/N 1U50716-02
S/N 000006R2
HOLE
INSIDE
OUTSIDE
BURN THRU
1-1/2" X 4"
TWO 1/2" DIA HOLES
312°
311°
INSULATION
28"
23 HOLES
HALF HOLE
INSIDE A-A
OUTSIDE
TAPERED REGION
1.12"
FWD STUB
HEAVY CORROSION
268°
269°
*TWO BUSHINGS
FWD
9"
2.5"
CTR 300°
HALF HOLE
30"
HALF HCLE
NO HOLES
AFT STUB
250°
220°
41"
76.75
21.5" 18 HOLES
18" ERODED REGION NO HOLES
31" 28 HOLES
11.25"
71"
114.75"
FRACTURE
21"
HEAVILY SOOTED REGION CAN BE RUBBED OFF TO SHOW WHITE PAINT
WHITISH DISCOLOR
CORRODED REGION
47"
42.25" AFT STUB ERODED REGION
EXTERIOR SURFACE
18"
FRACTURE
104"
320°
240°

Figure 79. Contact 712, RH Aft Segment Attach Segment, Exterior Surface

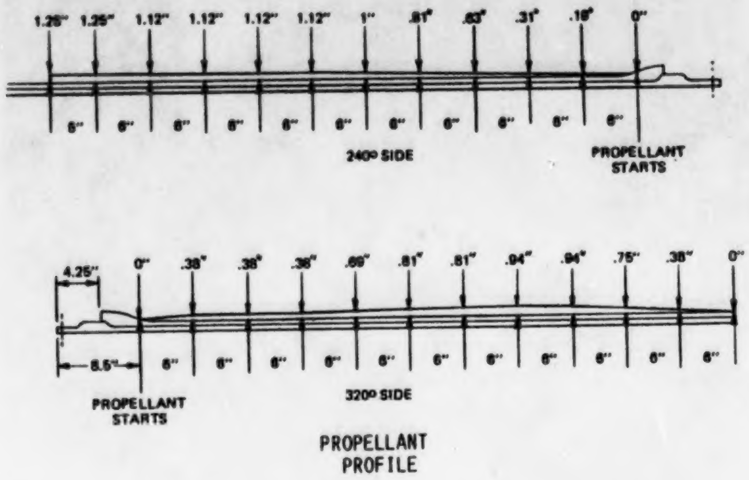
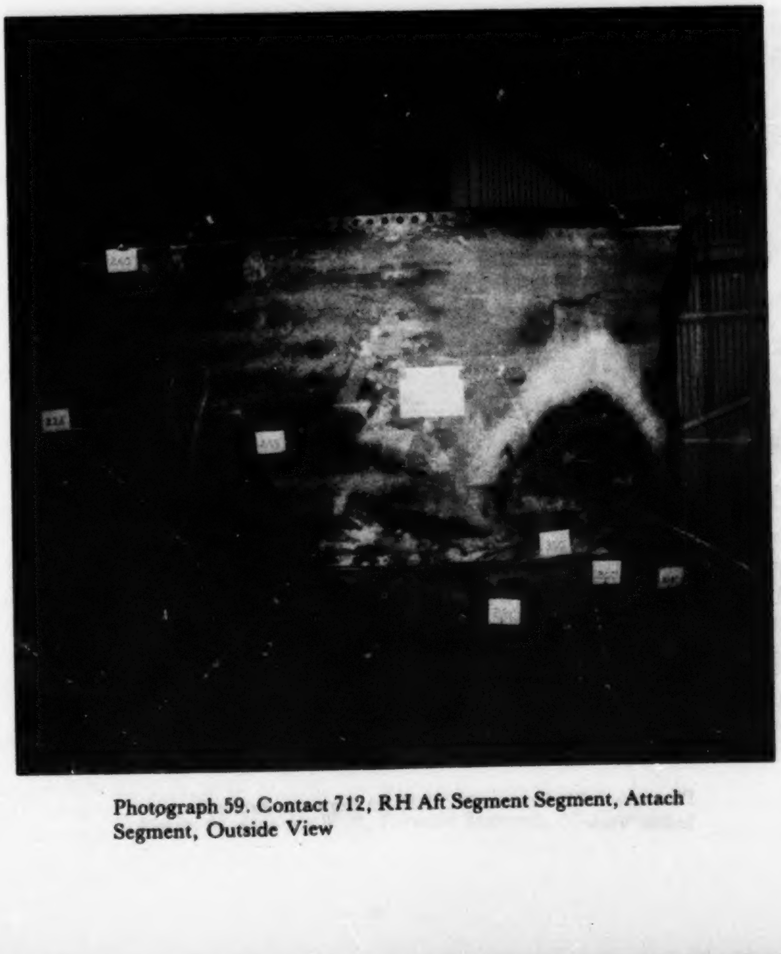
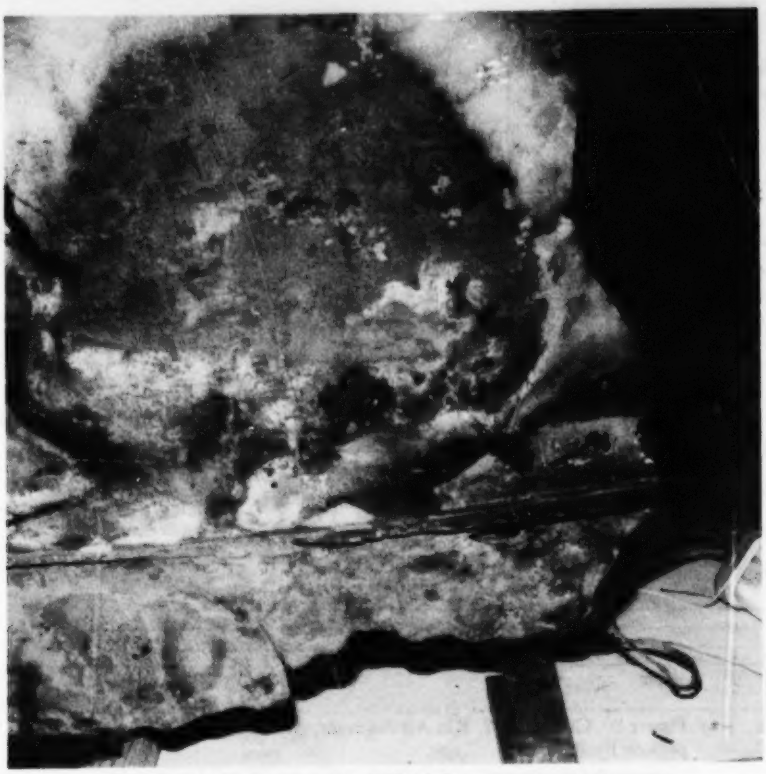

1.25"
1.25"
1.12"
1.12"
1.12"
1.12"
1"
.81"
.63"
.31"
.19"
0"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
240° SIDE
PROPELLANT STARTS
4.25"
0"
.38"
.38"
.38"
.69"
.81"
.81"
.94"
.94"
.75"
.38"
0"
8.5"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
6"
320° SIDE
PROPELLANT STARTS
PROPELLANT PROFILE

Figure 80. Contact 712, RH Aft Segment, Attach Segment, Propellant Profile

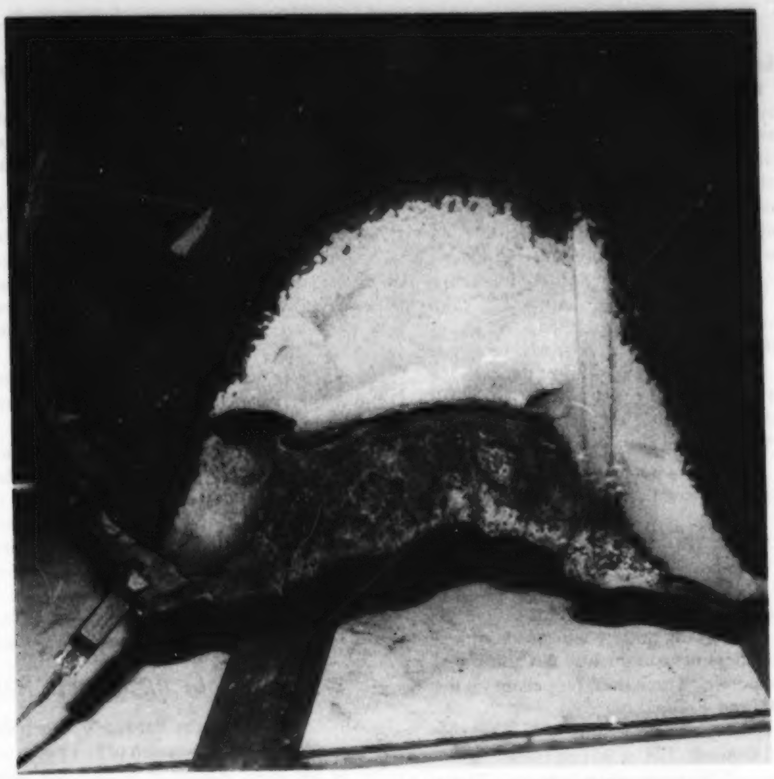


Photograph 59. Contact 712, RH Aft Segment Segment, Attach Segment, Outside View



Photograph 60. Contact 712, RH Aft Segment, Attach Segment, Outside Closeup View

Photograph 61. Contact 712, RH Aft Segment, Attach Segment, Inside View



Photograph 62. Contact 712, RH Aft Segment, Attach Segment, Inside Closeup View

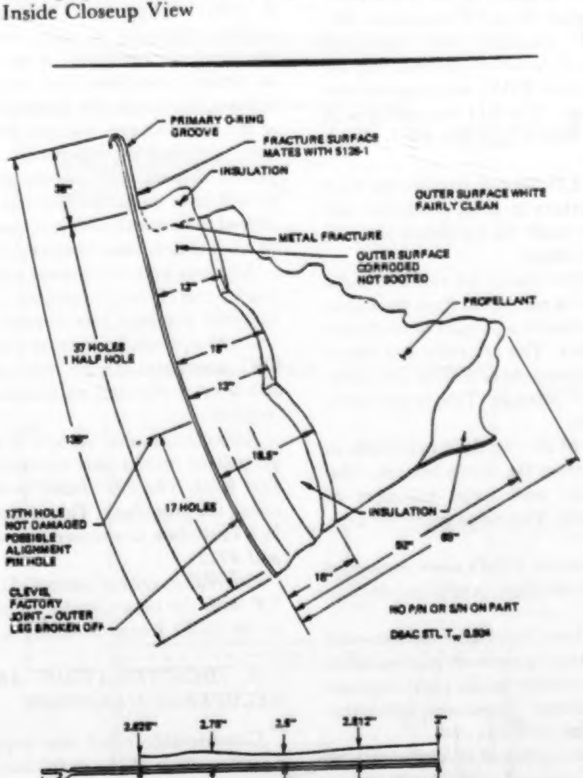

PRIMARY O-RING GROOVE
FRACTURE SURFACE MATES WITH 5126-1
INSULATION
OUTER SURFACE WHITE FAIRLY CLEAN
METAL FRACTURE
OUTER SURFACE CORRODED NOT SOOTED
PROPELLANT
38"
12"
18"
12"
27 HOLES 1 HALF HOLE
139"
18.5"
17TH HOLE NOT DAMAGED POSSIBLE ALIGNMENT PIN HOLE
17 HOLES
INSULATION
52"
66"
18"
CLEVIS FACTORY JOINT – OUTER LEG BROKEN OFF
NO P/N OR S/N ON PART
D6AC STL T_W 0.504
2.626"
2.75"
2.5"
2.812"
3"
18"
12"
12"
12"
12"
DATUM DWL LINE

Figure 81. Contact 5038, Forward Segment, Aft Cylinder

CONTACT #5038—This part was identified as a fragment of an aft cylinder, forward segment, RH or LH SRB unknown. Identification was made by propellant burn back profile analysis. No further identifying features were apparent. Approximately 70% of the interior surface was covered with propellant. (Reference Figure 81 and Photograph 63.)

CONTACT #5039—This part has been identified as a fragment of a case cylinder. the tang on the part cannot be identified as a factory or field joint because the insulation is missing. There is no propellant on the part. (Reference Figure 82 and Photograph 64.)

CONTACT #5124—This part has been identified as an upper diagonal strut, LH SRB. Identification was made by serial number (2000012) found on the strut. Fragments of the external tank and SRB attach ring are attached to the ends of the strut. (Reference Figure 83 and Photograph 65.)

CONTACT #5126-1—This part has been identified as a fragment of an aft cylinder, forward segment, RH or LH SRB unknown. No other identifying features are apparent. Approximately 60% of the interior surface is covered with propellant. Insulation is present where the propellant is missing. (Reference Figure 84 and Photograph 66.)

CONTACT #5126-2—This part has been identified as a fragment of a case cylinder, forward segment, LH or RH SRB unknown. This fragment has no tang and no clevis. Identification was based on wall thickness measurements. No additional identifying features were apparent. There is no propellant on the part. (Reference Figure 85 and Photograph 67.)

CONTACT #5128—This part has been identified as a fragment of a case cylinder, forwward segment, LH or RH unknown. Identification was based on case wall thickness measurements. There is no propellant on the part and the majority of the internal insulation is missing. (Reference Figure 86 and Photograph 68.)

FRUSTUM—The LH and RH frustums were recovered floating on the ocean surface. The LH frustum was relatively intact with forward BSM's attached. These BSM's were later removed and are now on the EOD Range. The RH frustum was in good shape except for the missing BSM's, Contact #497, which were located on the ocean bottom.

DROGUE PARACHUTE—The LH drogue parachutes were recovered folating on the ocean surface in good condition and attached to the frustum. this part could be identified by part number and serial number on the chute.

TVC HYDRAULIC RESERVOIR—One of the two hydraulic fluid reservoirs from the RH SRB was recovered from the ocean bottom. The reservoir was still attached to a portion of the frame used to mount the unit to the aft skirt. The reservoir and frame were identified using part and serial numbers still on the hardware. Both items suffered extensive damage. This helps verify the location of the RH SRB debris.

TVC FLUID MANIFOLD—One of the two fluid manifolds in the RH SRB was recovered intact from the ocean bottom. The manifold was identified using part and serial numbers of subassemblies installed on the manifold. This helps verify the location of the RH SRB debris.

FORWARD BSM'S—The LH forward BSM's were recovered intact in the frustum. They were in excellent condition with the ignitors and nozzles present.

RATE GYRO PANEL—The LH Rate Gyro Panel was retrieved on a piece of forward skirt upper ring segment. A part number on the panel and a problem report number on the right segment aided in the identification of this hardware. There were identification plates on the gyros to aid in the identification.

AFT IEA—A fragmented section of a piece of IEA housing was found in the unidentified area of the impound room. A transducer with a part number and serial number were located on this piece. It has been verified as being the absolute pressure transducer for the LH Aft IEA.

SRB CABLE—A piece of an SRB Cable was retrieved by a shrimp boat. On the cable was a visible part number, serial, number, and reference designator of the part. It has been identified as being a RH Aft tunnel cable.

SRB CABLE—Another cable was found intact attached to a support bracket from the ETA ring. It was identified from the part number and serial number as being from the LH upper strut assembly.

ET ATTACH RING COVER AND ETHYLENE PROPYLENE DIENIE MONOMER (EPDM) STRUT COVER—An ET attach Ring cover and an EPDM Upper Strut cover were recovered from the impact area. Both items were attached to each other. The part numbers and serial numbers were clearly visible on the inside of each cover which aided in their identification.

SYSTEM TUNNEL COVER—The LH forward skirt system tunnel cover was retrieved in good condition in the impact area. It has been verified as the LH forward skirt system tunnel cover by part number and serial number.

MISCELLANEOUS—The majority of the remaining recovered SRB hardware was retrieved floating in the impact area. These included flotation foam pieces from the frustum, fragmented halves of system tunnel covers and floor assemblies, and pieces of electronic PC boards and associated attaching hardware.

Sections of forward skirt skin were recovered, two with Range Safety Antenna attached and one with an IEA support bracket base attached. The remaining sections had nothing attached. Also recovered was part of an internal forward skirt inner ring section.

VI. *DISPOSITION OF RECOVERED HARDWARE*

After recovery of the hardware and transportation to shore, parts were secured on wooden pallets and trucked to either Hangar "O" or the EOD Range in accordance with the "Plan for SRB Salvage Off-Load and Transport to Storage Facility," dated March 6, 1986 (see Appendix C). Due to safety concerns about the propellant remaining on some parts, access for physical analysis of the parts was restricted. After an assessment of potential means to remove propellant (i.e., water laser, hand cutting, chemical solvent, burning), the decision was made to burn the propellant at the EOD Range. Various precautions (water, putty, etc.) were used to protect the parts from further extensive damage (see propellant disposal plan in Appendix D). All parts either have had or will have the propellant removed by burning with the exception of the critical evidence, parts #131 and #712. Part #579 will be used to determine methods for a safe removal of the propellant.

All parts were extensively photographed, dimensional sketches made, and chemical samples taken prior to burning of any part to avoid potential loss of data.

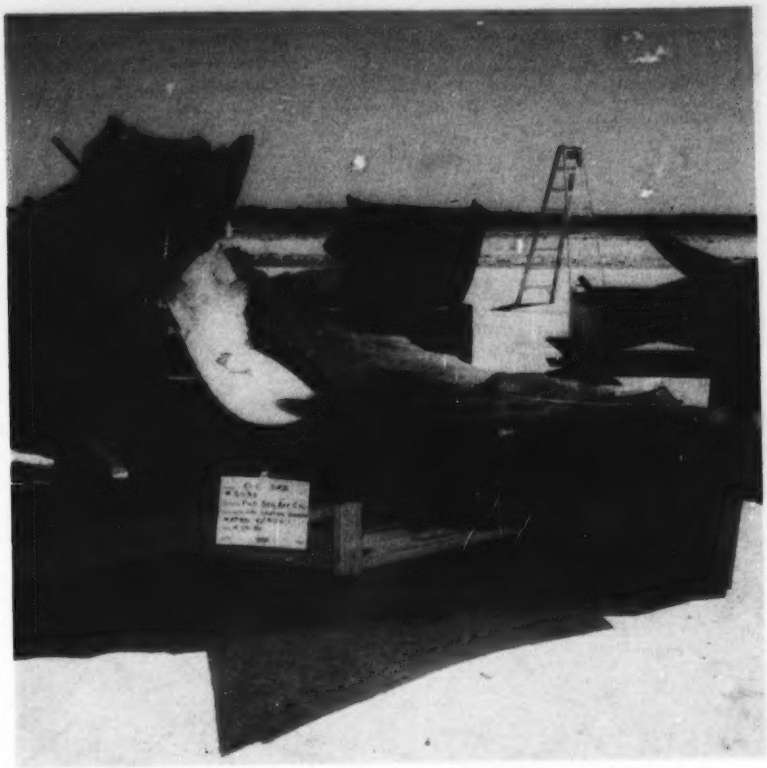
Other operations, such as cutting of metallurgical samples by LSC, soot/paint sample removal, and insulation removal, have also been performed on Contact #301, to aid in the hardware analysis.

An evaluation of the use of an LSC to cut a section without propellant from a part containing propellant was conducted on part #502. The LSC failed to sever the part and resulted in igniting the propellant. This method was subsequently discontinued as a candidate to remove propellant from the critical part #131 and #712.

Currently, critical parts #131 and #712 are located in Hangar "O" with the other hardware in either the Hangar "O" area or at the EOD Range awaiting a decision on further disposition.

A. *IDENTIFICATION AND RECONSTRUCTION OF RECOVERED HARDWARE*

Considerable effort was expended in the identification and reconstruction of the individual pieces of recovered SRB hardware. Where possible, positive identification was made by part numbers and serial numbers found on the parts. Other identification methcds employed included design features, propellant burnback analysis, paint patterns and insulation char patterns. Methods and devices used to reconstruct the individual parts included dimensional analysis of fracture patterns, design features



Photograph 63. Contact 5038, Forward Segment, Aft Cylinder

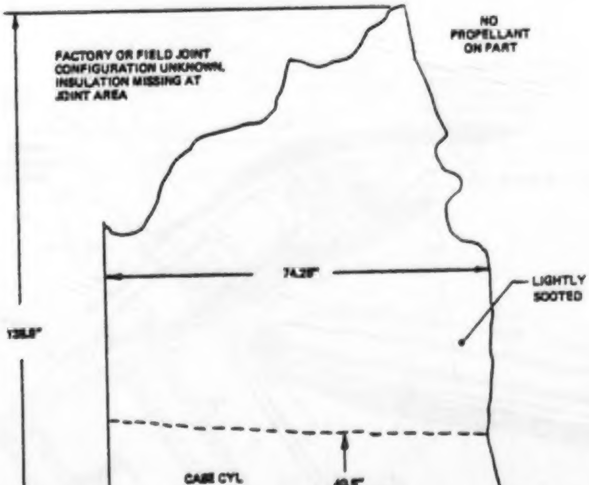
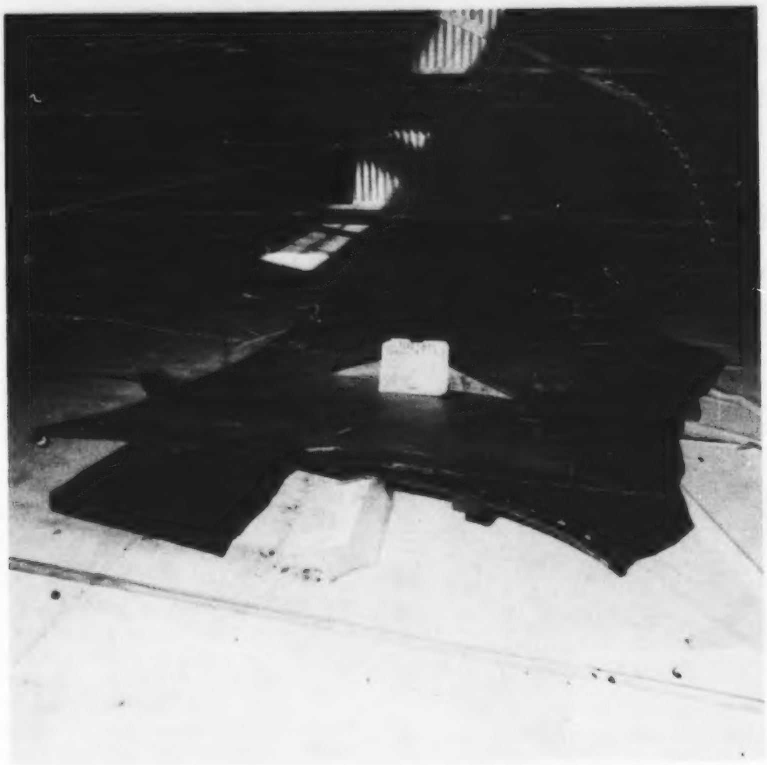

FACTORY OR FIELD JOINT
CONFIGURATION UNKNOWN,
INSULATION MISSING AT
JOINT AREA
NO
PROPELLANT
ON PART
74.25"
LIGHTLY
SOOTED
135.5"
CASE CYL
40.5"
INSULATION
GONE
HALF
HOLE
TANG
250°
240°
230°
1.5"
24 HOLES
4
HOLES
76.25"

Figure 82. Contact 5039, Case Cylinder Fragment



Photograph 64. Contact 5039, Case Cylinder

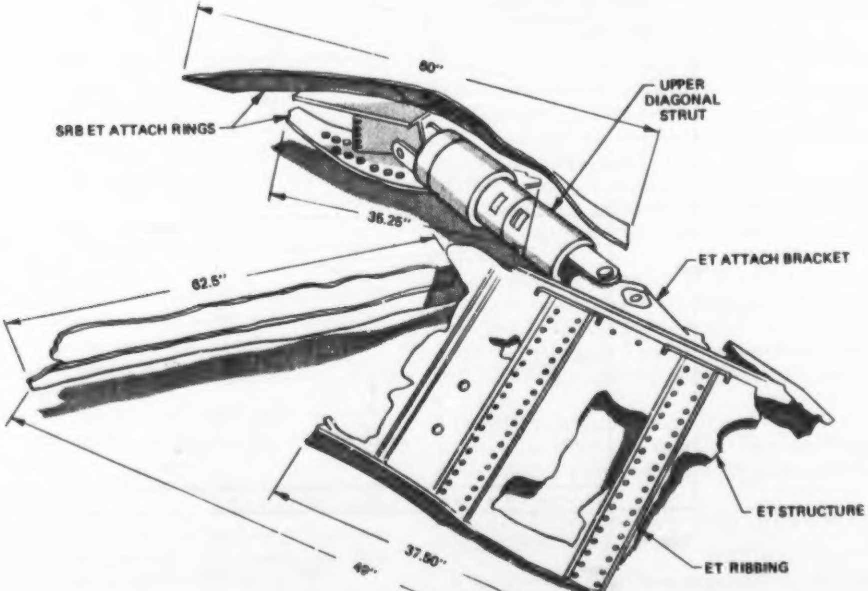
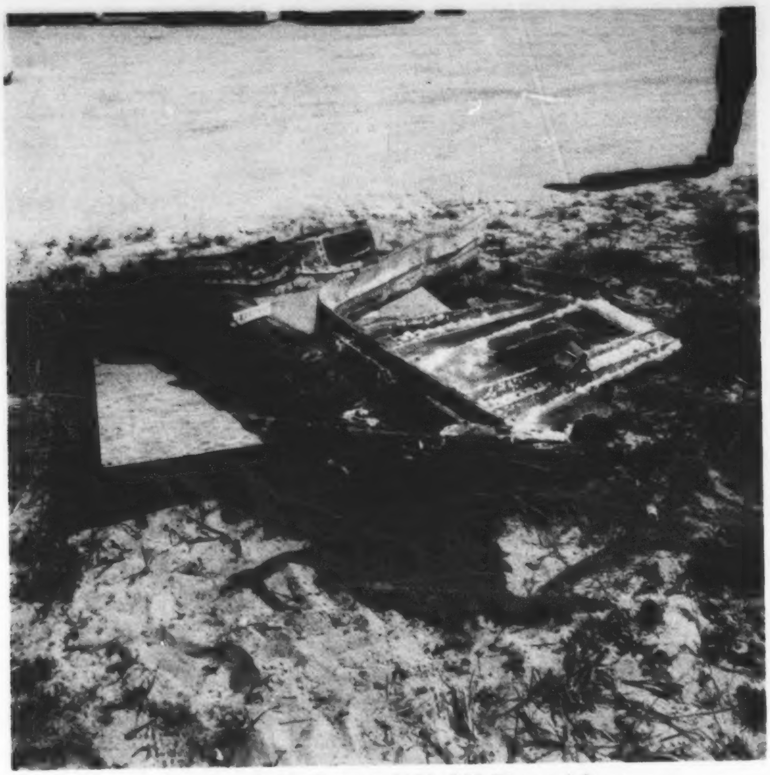

80"
UPPER DIAGONAL STRUT
SRB ET ATTACH RINGS
35.25"
62.5"
ET ATTACH BRACKET
ET STRUCTURE
37.50"
49"
ET RIBBING

Figure 83. Contact 5124, LH Diagonal Strut



Photograph 65. Contact 5124, LH Diagonal Strut

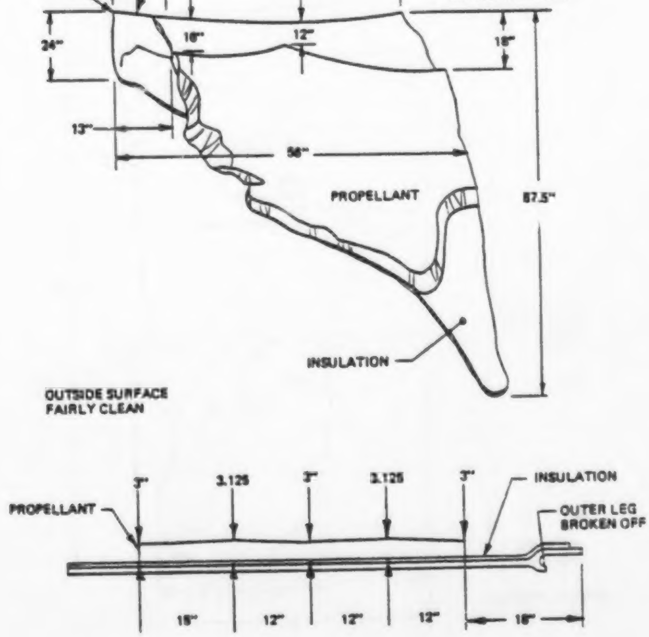
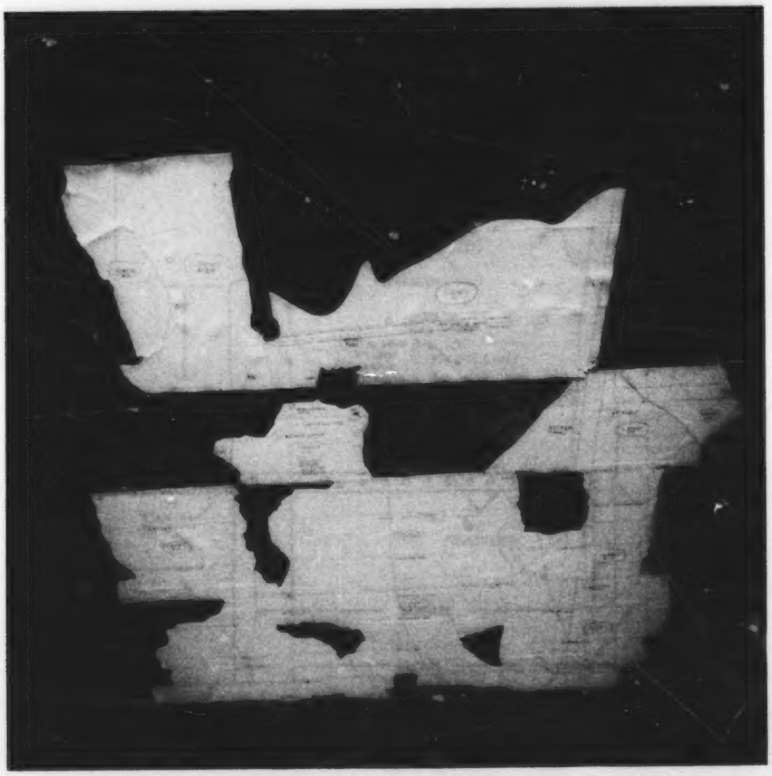

CLEVIS
(FACTORY JOINT)
19 HOLES
1 HALF HOLE
HALF HOLE
50"
41"
SHEARED OFF FWD FACE OF SECONDARY GROOVE FRACTURE SURFACE MATES WITH 5038
24"
16"
12"
18"
13"
56"
PROPELLANT
87.5"
INSULATION
OUTSIDE SURFACE FAIRLY CLEAN
3"
3.125
3"
3.125
3"
INSULATION
PROPELLANT
OUTER LEG BROKEN OFF
18"
12"
12"
12"
18"

Figure 84. Contact 5126-1, Forward Segment Aft Cylinder

Photograph 68. Contact 5128, Forward Segment, Case Cylinder



Photograph 69. Reconstruction of Aft Segment

such as forward and aft dome, stub skirts, ring stubs, alignment devices, the systems tunnel and templates. Reconstruction of the RH aft segment was accomplished by use of the templates. The templates were traced directly from each part on a flexible foam material. The traced shapes were cut from the foam sheets, rolled out flat, and placed on a dedicated floor space in Hangar AF. Each template, representing a specific part, was placed in position on the floor with respect to other parts of the pattern, resulting in the construction of a full-scale composite picture of recovered hardware. This method proved very successful in identification and placement within the SRB of previously unidentified parts and provided information relative to shape, size, and location of missing parts. Reference Photograph 69.

B. *PERCENTAGE OF RECOVERED SRM HARDWARE*

Percentage of the recovered SRM hardware has been estimated by comparing the surface area of the fragments recovered to the actual surface area of the SRM's. The forward skirt, aft skirt, forward exit cone and aft exit cone were not included in the calculations. The results are shown on Table V (reference Figures 87 and 88).

TABLE V

Total SRM Surface Area

Forward Segment	– 168,244 in^2
Forward Center Segment	– 150,444 in^2
Aft Center Segment	– 150,444 in^2
Aft Segment	– 182,497 in^2
TOTAL	651,629 in^2

Recovered Hardware	*Approximate In^2*	*Approximate % of Total for One SRM*
Right-Hand SRM Surface Area	239,738	37%
Left-Hand SRM Surface Area	91,243	14%
Unknown SRM Surface Area	96,039	15%

	Approximate In^2	*Approximate % of Total for Two SRM's*
Total Recovered SRM Surface Area	427,020	33%

C. *PROPELLANT DISPOSAL OPERATIONS*

Propellant remaining on the insulation and steel case fragments and bulk propellant with the exception of parts #131, #712, and #579 was disposed of by procedures approved by applicable Search, Recovery and Reconstruction Team members. (Reference Appendix D for the original disposal plan and Photographs 70, 71, and 72 for disposal configuration.)

VII. SUMMARY AND FINDINGS

Reviews of the visual data (film/video) of the STS 51-L mission indicated a flame source in the area of Station 1491.48 field joint at approximately the 300° circumferential location on the RH SRB. Two pieces of hardware were recovered and analyzed to confirm the source location of the failure. The part located at Sonar Contact #131 was determined by part number and serial number found on the case wall to be part of the RH SRB aft center segment. The tang end, which mates with the aft segment ET attach segment, was found to contain a burned area in the circumferential location from 294° to 316°. Another part located at Sonar Contact #712 was determined by a comparison of the part's features as documented in manufacturing records and the recovered hardware to be a piece of the RH aft segment ET attach segment. It also contained a burned-out area in the circumferential location of 291° to 318°. After examination by personnel from MSFC, JSC, NTSB, and others, it has been concluded that the source of the flame seen in the STS 51-L visual records was in the area of the RH aft center to aft segments field joint in the 291° to 318° circumferential location. Findings from a detailed examination and analysis of the parts is published in a separate report.

Other SRB parts recovered were examined for evidence of abnormal flight operation but none were noted. However, it should be stated that the condition of the hardware caused by the explosion, range destruct, water impact, subsequent impact with the ocean bottom, exposure to the ocean environment for almost three months, and subsequent recovery operations resulted in a major inability to assess anomalous flight conditions. A combustion gas blowby at the joint O-rings is normally determined by examination of the O-rings for erosion or sooting and of the O-ring grooves and lands for soot deposits or burned grease. No O-rings from the 51-L SRB joints were found and, due to the environments that the metal experienced, evidence of blowby on the grooves could have easily been removed.

In conclusion, it is believed that the Search and Recovery operation to find evidence to confirm the flame source location was highly successful, but the recovered hardware is of minor value relative to cause of the failure at the joint.

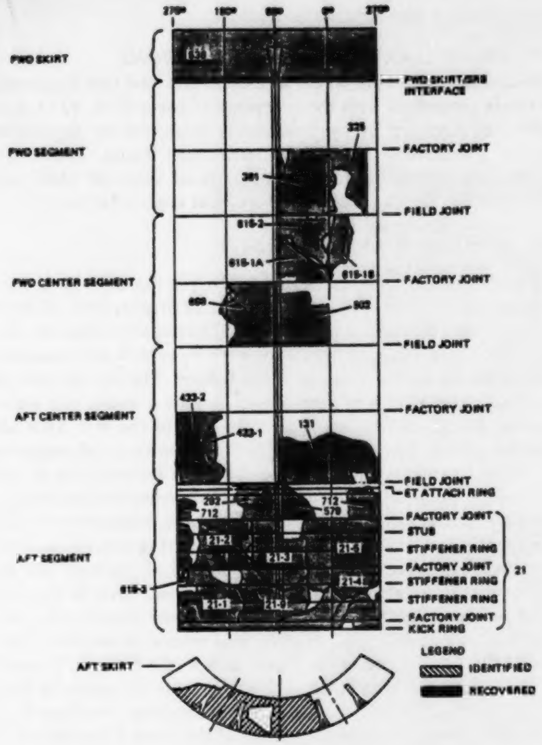

270°
180°
90°
0°
270°
FWD SKIRT
FWD SKIRT/SRB INTERFACE
FWD SEGMENT
325
FACTORY JOINT
381
FIELD JOINT
615-2
615-1A
615-1B
FACTORY JOINT
FWD CENTER SEGMENT
650
502
FIELD JOINT
433-2
AFT CENTER SEGMENT
FACTORY JOINT
433-1
131
FIELD JOINT
ET ATTACH RING
202
712
712
579
FACTORY JOINT
STUB
21-2
21-5
STIFFENER RING
21-3
FACTORY JOINT
AFT SEGMENT
21
615-3
21-4
STIFFENER RING
21-1
STIFFENER RING
FACTORY JOINT
KICK RING
AFT SKIRT
LEGEND
IDENTIFIED
RECOVERED

Figure 87. RH SRB Recovered Debris

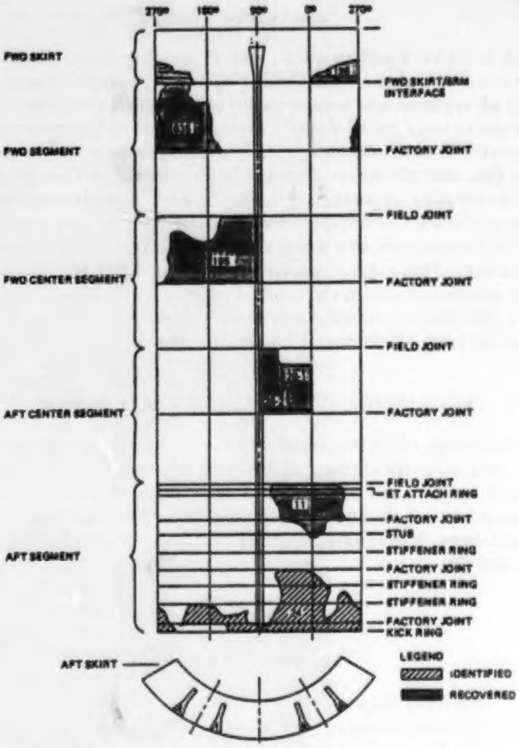

270°
180°
90°
0°
270°
FWD SKIRT
FWD SKIRT/SRM INTERFACE
FWD SEGMENT
FACTORY JOINT
FIELD JOINT
FWD CENTER SEGMENT
FACTORY JOINT
FIELD JOINT
AFT CENTER SEGMENT
FACTORY JOINT
FIELD JOINT
ET ATTACH RING
FACTORY JOINT
STUB
AFT SEGMENT
STIFFENER RING
FACTORY JOINT
STIFFENER RING
STIFFENER RING
FACTORY JOINT
KICK RING
AFT SKIRT
LEGEND
IDENTIFIED
RECOVERED

Figure 88. LH SRB Recovered Debris

Photograph 70. Contact 26-1, Propellant Burn, Putty Installation

Photograph 71. Contact 26-1, Propellant Disposal, Temperature Sensor Installation

Photograph 72. Contact 26-1, Propellant Disposal, Water Deluge

APPENDIX A
REPORT FOR SIGHTINGS OF SRB OR SRM
UNDERWATER VIDEO LOG

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POSITION    DESCRIPTION                                      ORBITER     TARGET
                                                             SYSTEM      NUMBER

** TAPE NUMBER   : 008

* SOURCE OF TAPE : 2-15-86:P+T BFR & 2-16-86:SRB Segment, Deep Drone #1
665-END     LH AFT SECTION WITH ETA RING                     SRB

** TAPE NUMBER   : 010

* SOURCE OF TAPE : Fixed Camera with Deep Drone #1
868-890     LOOKS LIKE A SEGMENT, VISIBILITY VERY POOR       SRB

** TAPE NUMBER   : 011

* SOURCE OF TAPE : Fixed Camera with Deep Drone #2
ALL         COMPLETELY OUT OF FOCUS                          SRB

** TAPE NUMBER   : 012

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 1
266         INSIDE AFT SKIRT,PART OF KICK RING               SRB            0
282         NOZZLE, BLAST SHIELD FOR LSC (UPSIDE DN)         SRB            0
324         BSM, ANOTHER VIEW                                SRB            0
380         AFT STRU, END OF AFT SKRT INT.COSTAL RIB         SRB            0
430         FWD NOZZLE EXIT CONE STRU. HOUSING               SRB            0

** TAPE NUMBER   : 013

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 2
123         AFT SKIRT STRU. EXT. VIEW LOOKING INWARDS TO     SRB            0
            TVC
142         STRUCTURE ? (BRKT)                               SRB            0
171         STRUCTURE ?                                      SRB            0
198         TVC SYST BKT                                     SRB            0
214         TVC MANIFOLD                                     SRB            0
228         AFT SKRT,T-RING,FASTENERS,GUSSETS,CLIPS,POS.     SRB            0
            FUEL ISO VALVE
314         BOTTOM OF AFT SKIRT                              SRB            0
450-470     POSSIBLE AFT DOME, SEE GLASS WRAP                SRB            0

** TAPE NUMBER   : 014

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 3
034-038     STRUTURAL MEMBER,NOZZLE FIXED HOUSING, GUIDE     SRB            0
            PIN, BOLT HOLES
118         FUEL ISO VALVE ATTACH STRUCTURE                  SRB            0
186         CYLINDER SECTION OF SRM                          SRB            0
282         SECTION OF KICK RING                             SRB            0
365         AFT SKIRT WITH BSM                               SRB            0
434         AFT SKIRT STRUCTURE - AFT ATTACH BSM             SRB            0

** TAPE NUMBER   : 015

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 4
018         ACTUATOR ATTACH BRACKET - AFT SKIRT              SRB            0
060         TUNNEL FLOOR PLATE AND ROOSTER TAIL              SRB            0
087-090     PHENOLIC                                         SRB            0
102         ALUMINIM SKIN - AFT SKIRT                        SRB            0
142         AFT SEGMENT STIFFENER "T" RING                   SRB            0
177         PIN RETAINER BAND                                SRB            0
199 & 218   NOZZLE GLASS PHENOLIC                            SRB            0
240         STIFFENER RING                                   SRB            0
244         NOZZLE GLASS PHENOLIC                            SRB            0
256         AFT STRUCTURE STIFFENER                          SRB            0
263         GLASS PHENOLIC RING & UNIDENTIFIED AL.           SRB            0
            STRUCTURE BRACKET
271         NOZZLE GLASS PHENOLIC                            SRB            0
290         SHORT SECTION TUNNEL COVER                       SRB            0
311         NOZZLE THROAT CARBON PHENOLIC RING               SRB            0
325         PHENOLIC GLASS                                   SRB            0
352         PHENOLIC GLASS AND CARBON RING AREA              SRB            0
374         PHENOLIC GLASS                                   SRB            0
398         CARBON PHENOLIC RING AND RECTANGULAR PLATE ?     SRB            0
412         ALUMINUM SHEET FRAGMENT                          SRB            0
417         PHENOLIC GLASS                                   SRB            0
431         AFT INTERNAL RING FRAGMENT ?                     SRB            0
455         PHENOLIC GLASS                                   SRB            0
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                         UNDERWATER VIDEO LOG

POSITION    DESCRIPTION                                 ORBITER    TARGET
                                                        SYSTEM     NUMBER


** TAPE NUMBER   : 016

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1244, TAPE 5
030          AFT SECTION WITH INSTAFOAM (SMALL)         SRB             0
070-090      PHENOLIC GLASS                             SRB             0
125          KICK RING PHENOLIC COVER                   SRB             0
181          CARBON PHENOLIC NOZZLE                     SRB             0
189          LINEAR SHAPE CHARGE (NOZZLE SEVERANCE)     SRB             0
201-202      PHENOLIC GLASS                             SRB             0

** TAPE NUMBER   : 017

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1245, TAPE 1
061-410      ALL VIEWS OF SEGMENT ARE EXTERIOR          SRB             0
294          PIN RETAINER BAND                          SRB             0
300          KICK RING                                  SRB             0
366          AFT SKRT & SEGMENT(KICK RING,AFT CLOSURE,AFT SRB           0
             STIFFENER SEG)
423          FWD EXIT CONE HOUSING,EXT VERY SOOTED,STRU SRB             0
             DAMAGE TO JOINT


** TAPE NUMBER   : 018

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1245, TAPE 2
022          AFT SKIRT FRAGMENTS                        SRB             0
026          SMALL AFT SKIRT FRAGMENTS                  SRB             0
089          TVC APU SYSTEM WITH HYDRAULIC PUMP         SRB             0
119-180      SUB OPERATOR DESCRIBED OBJECT AS PART OF EXIT SRB          0
             CONE
251          AFT SKIRT RING AND SKIN FRAGMENT           SRB             0
346          GLASS PHENOLIC                             SRB             0
359          SECTION OF AFT SKIRT                       SRB             0
365          AFT SKIRT AFT RING FRAGMENT                SRB             0
374          POSSIBLE NOZZLE SNUBBER                    SRB             0
414          FWD EXIT CONE HOUSING                      SRB             0
448          AFT SKIRT SEGMENT                          SRB             0
450          PART OF UPPER TVC FRAME AND HYDRAULIC      SRB             0
             RESERVOIR

** TAPE NUMBER   : 019

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1246, TAPE 1
016          SMALL UNIDENTIFIED FRAGMENT                SRB             0
044          ELECTRICAL CABLE                           SRB             0
062          INTERNAL PLATES OF HDP                     SRB             0
082          AFT SKRT STRUC.,SECTION OF MID-RING FOAM &   SRB           0
             SKIN PNL,4x4 ft
143 & 156    AFT SKIRT FRAGMENT                         SRB             0
164          FEED THRU ASSEMBLIES (ROOSTER TAIL & TUNNEL  SRB           0
             FLOOR)
182          AFT SKIRT FRAGMENT                         SRB             0
190          ALUMINUM FRAGMENT                          SRB             0
208          CASE SEGMENT STIFFENER RING WITH SPLICE JOINT SRB          0
217          LOWER TVC FRAME SECTION & HYDRAULIC RESERVOIR SRB          0
             CLAMP
236-284      CASE SEGMENT SHOWING TANG WITH TANG SLOT   SRB             0
316-338      AFT SKRT STRUC. TRAILING EDGE (3x12 ft) &  SRB             0
             WHALEBONE
394          AFT SKIRT FRAGMENT                         SRB             0
409          AFT SKIRT FRAGMENT WITH CORK AND RING SHIMS  SRB           0
439          NOZZLE CARBON PHENOLIC - INTACT            SRB             0
456          UNIDENTIFIED NOZZLE RING WITH FLAP         SRB             0
478          CLEVIS RING JOINT - POSSIBLE O-RING GROOVE   SRB           0

** TAPE NUMBER   : 022

* SOURCE OF TAPE : DEEP DRONE PAN & TILT PART 1
596          PN #127527-1??                             SRB


** TAPE NUMBER   : 023

* SOURCE OF TAPE : DEEP DRONE PAN & TILT PART 2
0-160        THIN SKINNED STRUCTURE WITH RIBS           SRB

** TAPE NUMBER   : 028

* SOURCE OF TAPE : DEEP DRONE PAN & TILT TAPE 1
009-535      AFT SKIRT                                  SRB
535-END      FORWARD SKIRT                              SRB

** TAPE NUMBER   : 029

* SOURCE OF TAPE : DEEP DRONE PAN & TILT TAPE 2
001-510      FWD SKIRT                                  SRB
510-609      CANNOT IDENTIFY A RING WITH A SPRING ON END. SRB
             1 1/2 DIA 3 TO4 INCHES LONG
609-END      SCATTERED DEBRI, THERMAL CURTAINS, THERMAL SRB
             CURTAIN RETAINERSWHALE BONE, AFT SKIRT RIBS
             WITH SOME SKIN, BLACK BOX AFT    SKIRT
             STIFFENERS OR FWD??
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                              UNDERWATER VIDEO LOG

POSITION   DESCRIPTION                                    ORBITER     TARGET
                                                          SYSTEM      NUMBER

** TAPE NUMBER   : 030

* SOURCE OF TAPF : JOHNSON SEALINK II, DIVE #1247
020          TVC FRAME & TUBING WITH FLEXHOSE               SRB            0
051          STIFFENER RING - 90 DEGREES TUNNEL SPLICE      SRB            0
             AREA
071          GLASS PHENOLIC - NOZZLE                        SRB            0
102          GLASS PHENOLIC - SKIRT PARTS                   SRB            0
138          GLASS & CARBON PHENOLIC - NOZZLE               SRB            0
167          SYSTEMS TUNNEL - BOTTOM UP - AFT BOOSTER       SRB            0
             (WITH COVER)
191          EXHAUST DUCT OR TVC TUBING                     SRB            0
204          GLASS PHENOLIC                                 SRB            0
235          STIFFENER RING - 90 DEGREES TUNNEL SPLICE      SRB            0
             ARES
320          NOZ7LE RING CARBON                             SRB            0
340          AFT SKIRT SKIN                                 SRB            0
366          CARBON PHENOLIC - NOZZLE                       SRB            0
385          SMALL FRAGMENT                                 SRB            0
396          PHENOLIC, SMALL PIECE                          SRB            0
406          AFT SKIRT FRAGMENT                             SRB            0
415          AFT SKIRT FRAGMENT                             SRB            0
423          AFT SKIRT SKIN                                 SRB            0
436          UNIDENTIFIED RING                              SRB            0
442          CARBON PHENOLIC                                SRB            0

** TAPE NUMBER   : 031

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1248, TAPE 1
013          PIN RETAINER BAND                              SRB            0
116          CARBON & GLASS PHENOLIC - NOZZLE               SRB            0
177          CARBON PHENOLIC                                SRB            0
187          GLASS PHENOLIC                                 SRB            0
218          CARBON PHENOLIC                                SRB            0
264          LSC SILICONE RETAINER - NO CHARGE              SRB            0
293          TVC BRACKET                                    SRB            0
325          PIECE OF CURTAIN WITH RIVET HOLES, GLASS       SRB            0
             PHENOLIC
374          SKIN FRAGMENT                                  SRB            0
385          GLASS PHENOLIC                                 SRB            0
394          SKIN THERMAL CURTAIN                           SRB            0
409          GLASS PHENOLIC                                 SRB            0
427          GLASS PHENOLIC                                 SRB            0
438          CARBON PHENOLIC                                SRB            0
455          SKIRT FRAGMENT                                 SRB            0

** TAPE NUMBER   : 032

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1248, TAPE 2
011          GLASS PHENOLIC                                 SRB            0
145          NOZZLE, 3 FT SQUARE                            SRB
228          NOZZLE RING, APPROX. 30                        SRB
315          NOZZLE (YELLOW)                                SRB
402          NOZZLE (YELLOW BAND)                           SRB

** TAPE NUMBER   : 033

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1249
025          RH AFT BOOSTER ON SKIRT                        SRB
055          SKIN TUNNEL AREA PROPELLANT                    SRB
160          SKIN OF SEGMENT W/SYSTEMS TUNNEL AT STIFFENER  SRB
             RING

** TAPE NUMBER   : 034

* SOURCE OF TAPE : DEEP DRONE PAN & TILT, 2-16-86 - 2-19-86
001          AFT BOOSTER                                    SRB
060          AFT BOOSTER, ETA RING (LH) PARTIAL             SRB
ALL          PROBABLE PART OF LH SRM AFT SEGMENT            SRM            0
ALL          CIRC. SECTION OF SRM ET ATTACH RING SEGMENT    SRM            0
ALL          LENGTH FROM FWD FIELD JOINT TO FWD STIFFENER   SRM            0
             JOINT
ALL          SEGMENT SURFACE DOES NOT APPEAR TO BE SOOTED   SRM            0
ALL          INHIBITOR STUB REMAINING APPEAR NORMAL OVER    SRM            0
             180 CIRC.
ALL          NO PROPELLANT WAS NOTED                        SRM            0
ALL          ET ATTACH RING AFT JOINT HAS HOLES EXPOSED     SRM            0

** TAPE NUMBER   : 035

* SOURCE OF TAPE : DEEP DRONE FIXED 2-16-86 - 2-19-86
200-END      LH AFT BOOSTER ETA RING SECTION, POOR          SRB
             VISIBILITY

** TAPE NUMBER   : 036

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1250 OOC TARGET 26
             SRB SEGMENT CASE W/PROPELLANT                  SRB
120          LT WT CASE 1U50717-02, S/N #0000075R1,         SRB
             FACTORY JOINT TANG
300-END      SRB SEGMENT CASE W/PROPELLANT FIELD JOINT      SRB
             CLEVIS
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                            UNDERWATER VIDEO LOG

POSITION     DESCRIPTION                                    ORBITER    TARGET
                                                            SYSTEM     NUMBER


** TAPE NUMBER    : 037

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1250 OOC #26 TARGET 182
001-296      SRM CASE PIECE  S.N. 0000075R1, PART #         SRB           182
             1050717-02 WITH TANG PROPELLANT ABOUT 1.5"-2"
             THICK,  DEPTH - 234 FT
1-296        SRM CASE PIECE S.N. 0000075R1 PART             SRM             0
             #1050717-02 WITH TANG PRO
296          SRM CASE PIECE INHIBITOR AT JOINT &            SRM             0
             PROPELLANT GRAIN 2

* SOURCE OF TAPE : JOHNSON SEALINK II: DIVE #1250 OOC #26 TARGET 182
296-END      SRM CASE PIECE INHIBITER AT JOINT +            SRB           182
             PROPELLANT GRAIN APPOX. 2" THICK. SHOWS SHAPE
             CHARGE CUT?  CLEVIS END OUTER LEG BROKEN
             AWAY, 4.5 - 5 FT ARC, LENGTK - 8 FT, DEPTH -
             234 FT

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1250 OOC #26 TARGET 182
315          PIECE OF LH SRM STEEL SEGMENT - 8 FT LONG X    SRB
             4-5 FT CIRCUM   CLEVIS END OF FIELD JOINT
             SHOWING WITH INHIBITOR FLAP ALSO  SOME
             CHROMATE PUTTY VISIBLE.  PROPELLANT VISIBLE.
315          BASED ON HEIGHT OF INHIBITOR, PART APPEARS TO SRB
             BE ALSO AFT   CENTER SEGMENT
470          FWD CASE SEGMENT                               SRB
8            LARGE PIECE OF LH SRM, AFT CTR FWD CASE        SRB
             SEGMENT STEEL SEGMENT - 10 FT LONG X 7-8 FT
             CIRCUM, IDENT S/N 075r1 2" OF PROPELLANT
             VISIBLE ON CASE WALL

** TAPE NUMBER    : 041

* SOURCE OF TAPE : JOHNSON SEALINK II, DIVE #1257, OOC #41 (J5-1)
250          IGNITER                                        SRM             0
ALL          SRM DOME, IGNITER & FWD SKIRT SKIN & CLEVIS    SRM             0
             TANG 180


ALL          SRM DOME, IGNITER, & FWD SKIRT                 SRB

** TAPE NUMBER    : 042

* SOURCE OF TAPE : JOHNSON SEALINK II,DIVE #1257,OOC #41 (CONTINUATION)(J5-2)
190          FORWARD SKIRT AFT CLEVIS TANG                  SRM             0
198          FORWARD DOME WITH IGNITER                      SRM             0
200          IGNITER                                        SRM             0
ALL          SRM DOME, IGNITER & FWD SKIRT SKIN & CLEVIS    SRM             0
             TANG 180  .
ALL          SRM DOME,IGNITER & FWD SKIRT                   SRB

** TAPE NUMBER    : 044

* SOURCE OF TAPE : DEEP DRONE FIXED, TARGET 2 & 37, 2 OF 6
             SCATTERED DEBRI?  VEPY POOR VISABILITY         SRB

** TAPE NUMBER    : 049

* SOURCE OF TAPE : NR-1, TAPE #5 (DUPLICATE OF TAPE #057)
1789-1830    CONTACT 17 FROM PREVIOUS TAPE, HYDRAZINE       SRB             0
             BOTTLE
2100-3400    CONTACT #1 FROM PREVIOUS TAPE - AFT 1/3 OF     SRB             0
             AFT MOTOR CASE OR AFT SKIRT SEGMENT RIGHT SRB
             @ 10:28
4300         4x4 FT PIECE OF SRM SKIN W/TUNNEL, POSS. PART SRB              0
             OF 3RD STIFFNER RING BLACKENED 1285 DEPTH
             POSS. W/FACTORY JOINT IN MIDDLE, MID & UPPER
             STIFFENER RING PIECES,CABLES IN TUNNEL
             SECTION
4950-END     CABLE, CONTACT 94, POSSIBLY WITH STRAP, TIME   SRB             0
             14:02 HOURS

** TAPE NUMBER    : 053

* SOURCE OF TAPE : NR-1, TAPE #1, ID #001, AREA A
0500-2220    CONTACT #1, 28 49 14 N, 79 52 39 W, AFT        SRB
             SEGMENT SITTING ON AFT SKIRT
2872         3 STIFFENER RINGS 41 CLEVIS - SPREAD OPEN      SRB
             JOINTS BROKEN
2872         APPEARS TO BE INSIDE OF SKIRT                  SRB
2872         PAT COMMENT.  WOULD PROBABLY BREAK UP WHEN     SRB
             LIFTED
4706         NOZZLE THROAT. LOOKING DOWN 12-15 FT ACROSS X SRB
             6-7 FT OFF SURFACE
5580         BOOSTER SEPARATION MOTOR ON PIECE OF AFT       SRB
             SKIRT
ALL          RH AFT BOOSTER (PORTION) AND SCATTERED DEBRI   SRB
```

UNDERWATER VIDEO LOG

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POSITION    DESCRIPTION                                      ORBITER    TARGET
                                                             SYSTEM     NUMBER

** TAPE NUMBER   : 054

* SOURCE OF TAPE : NR-1, TAPE #2, ID #001, AREA A
0000-0140   FORWARD FIXED HOUSING (NOZZLE) CONTACT #8        SRB
1150        CONTACT #10, AFT BOOSTER                         SRB
1328        CONTACT 11                                       SRB

** TAPE NUMBER   : 056

* SOURCE OF TAPE : NR-1, TAPE #4, ID #001, AREA A
20          PIECES OF NOZZLE                                 SRB
ALL         VARIOUS SCATTERED DEBRI, NOZZLE                  SRB

** TAPE NUMBER   : 057

* SOURCE OF TAPE : NR-1, TAPE #5, ID #001, AREA A
ALL         SCATTERED DEBRIS, NOZZLE                         SRB

** TAPE NUMBER   : 058

* SOURCE OF TAPE : NR-1, TAPE #6, ID #001, AREA A
1250-1405   AFT SKIRT, ACTUATOR ROD BURIED IN SAND,          SRB
            ACTUATOR STIFFENER IN SKIRT
2660        BUNDLE OF RINGS?? NOT CLEAR                      SRB

** TAPE NUMBER   : 059

* SOURCE OF TAPE : NR-1, TAPE #7, ID #001, AREA A
2245        HYDRAZINE TANK                                   SRB
2270        HYDRAZINE BOTTLE 8' LONG OBJECT                  SRB
2395        HYDRAULIC RESERVOIR                              SRB
2479        RUTURED VIEW OF HYDRAZINE TANK                   SRB
2580        HYDRAZINE BOTTLE (RUPTURED) WITH HYDRAULIC       SRB
            ACTUATOR
2585        VIEW OF TVC FRAME AND HYDRAULIC RESERVOIR        SRB
2639        VIEW OF HYDRAULIC RESERVOIR (CLOSE UP)           SRB
2660        TVC LOWER FRAME (CLOSE UP)                       SRB
2880        HYDRAULIC ACTUATOR                               SRB
2959        NOZZLE PART CONTACT #148                         SRB
3060        SKIN 3' X 8' SEGMENT CONTACT #149                SRB
3185        NOZZLE PART 5' DIA 200 COMPLETE                  SRB
3300        3' X 8' SKIN                                     SRB
3370        AFT SKIRT SKIN WITH CABLES AND COMPONENT         SRB
            IDENTIFIED AS ACTUATOR
3496        PILE OF DEBRIS ACTUATOR                          SRB
4030        LARGE MASS OF METAL ACTUATOR                     SRB
4390        ACTUATOR?                                        SRB
4540        ACTUATOR                                         SRB
4613        120 NOZZLE PART, HEAVY PIECE LEFT CRATER IN      SRB
            SAND
4766        NOZZLE PART                                      SRB
4910        RING                                             SRB

4990        2' X 4' PIECE                                    SRB
5085        I BEAM TYPE MATERIAL                             SRB
5125        PORTION OF SKIRT                                 SRB
5235        SKIN PIECE FOLDED DIA APPROX 4'                  SRB
5238        NOZZLE PART 360 INTACT AROUND                    SRB
5250        CIRCULAR PIECE 270 INTACT (NOZZLE RING)          SRB
5325        8' LONG SKIN                                     SRB
5335        10' X 6' PARTIALLY COVERED WITH SAND             SRB
5590        15' LONG NOZZLE PIECE COMPLETE 180               SRB

** TAPE NUMBER   : 060

* SOURCE OF TAPE : NR-1, TAPE #8, ID #001, AREA A
0130        3' X 4' AFT SKIRT                                SRB
0487        3'X4' AFT SKIRT                                  SRB
1637        MOTOR SKIN & CONTINUED FROM TAPE POSITION        SRB
            1637 TILL 2295
2212        PORTION OF A RING SIGHTED AND "IN" CLIPS         SRB
2615        12'X8' SRB SKIN STIFFENER RING WAS LOCATED IN    SRB
            THE AREA BY   WHITE LINE.  SURFACE OF SKIN
            APPEARS CHARRED
2920        NOZZLE PARTS, COMPLIANCE RING                    SRB
3730        WHALE BONE, SNUBBER                              SRB
3940        1' LONG 6" WIDE                                  SRB
4120        6' DIAMETER CARBON MATERIAL FROM NOZZLE          SRB
4320        NOZZLE PIECE                                     SRB
5021        4' WIDE 20' IN LENGTH NOZZLE MATERIAL            SRB
5143        COMPLETE 360 FANALIC MATERIAL                    SRB
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                              UNDERWATER VIDEO LOG

POSITION   DESCRIPTION                                        ORBITER     TARGET
                                                              SYSTEM      NUMBER

 ** TAPE NUMBER   : 061

 * SOURCE OF TAPE : NR-1, TAPE #9, ID #001, AREA A
 0330           AFT SKIRT PIECE                                SRB
 0699           I BEAM FROM BULKHEAD                           SRB
 0945           RING COMPLETE NOZZLE MATERIAL                  SRB
 1035           HYDRAZINE BOTTLE, PREVIOUSLY SEEN              SRB
 1494           DEBRI                                          SRB
 1690           CRUMPLED INSULATION MATERIAL                   SRB
 2045           SKIRT WITH CONTROLS                            SRB
 2050           BOOSTER SNUBBER, TWISTED METAL                 SRB
 2360           TEN FEET LONG                                  SRB
 2777           NOZZLE RING                                    SRB
 3256           SEGMENT SKIN, APPEARED CHARRED                 SRB
 3600           PIECE OF MATERIAL 5' WIDE 4' LONG              SRB
 3600           PIECE OF I BEAM                                SRB
 3895           10' PIECE                                      SRB
 4460           PIECE OF PIPE AND 2 FT SQ PIECE OF MATERIAL    SRB
 4550           TWO PIECES OF NOZZLE MATERIAL                  SRB

 ** TAPE NUMBER   : 062

 * SOURCE OF TAPE : NR-1, TAPE #10, ID #001, AREA A
 1005           CONTACT 268 190 RING MAT'L NOZZLE              SRB
 1760           CONTACT 271, BLACK RING NOT IN VIEW            SRB
 3003           CONTACT 281 SKIN MATERIAL 2' X 3'              SRB
 4431           CONTACT 287, RING DIA  5' TO 6'                SRB
 4700           CONTACT 290, 10' X 10' SKIN MATERIAL,          SRB
                POSSIBLE ONE OF FWD SEGMENTS TANG JOIN
 5438           LOST VISUAL CONTACT MAINTAINED AUDIO           SRB

 ** TAPE NUMBER   : 063

 * SOURCE OF TAPE : NR-1, TAPE #11, ID #001, AREA A
 ALL            POSSIBLE SRB  - MISC DEBRIS                    SRB
 ALL            VIDEC WAS POOR IN TERMS OF MAJOR DEBRIS        SRB
                FINDINGS AND VISUAL QUALITY

 ** TAPE NUMBER   : 068

 * SOURCE OF TAPE : TAPE J6-1, TARGET #24, OOC#24, 2/24/86
 175            10182-0092-101 NUMBER FROM SYSTEM TUNNEL PART SRB
                ON/IN BOOSTER TAIL SECTION

 * SOURCE OF TAPE : JSL II, TAPE J6-1, TARGET #24, OOC#24, 2/24/86
 213            KICK RING ON AFT SEGMENT                       SRB

 ** TAPE NUMBER   : 069

 * SOURCE OF TAPE : SEALINK II, J6-3, OOC#24, 2/24/86
 100            RETRIEVED BOLT FROM ON TOP OF KICK RING        SRB
                PHENOLIC
 155            FEED THRU SYSTEM TUNNEL COVER/FLOOR ASSEMBLY   SRB

 ** TAPE NUMBER   : 070

 * SOURCE OF TAPE : JSL II, J6-2, 2/24/86
 100            AFT SEGMENT ABOVE KICK RING WITHOUT PHENOLIC   SRB
                COVERS

 * SOURCE OF TAPE : J6-2, 2/24/86
 105            AFT FEED THRU ABOVE KICK RING ON AFT SEGMENT   SRB
 350            SYSTEM TUNNEL AT KICK RING ON AFT SEGMENT      SRB
 363            AFT SKIRT KICK RING PHENOLIC ON AFT SEGMENT    SRB

 ** TAPE NUMBER   : 072

 * SOURCE OF TAPE : DEEP DRONE, DIVE #29, FIXED, OOC #56
                STRUCTURE THIN SKINNED W/RIBS CANNOT IDENTIFY  SRB

 ** TAPE NUMBER   : 075

 * SOURCE OF TAPE : DEEP DRONE, CONTACT #11, PAN & TILT
                LEFT AFT BOOSTER WITH ETA RING, IDENTIFIED IN  SRB
                EARLIER TAPES, FIRST TARGET TO BE RETRIEVED,
                TAPE 008 AND 035

 ** TAPE NUMBER   : 076

 * SOURCE OF TAPE : DEEP DRONE, CONTACT #11
                LEFT AFT BOOSTER WITH ETA RING, IDENTIFIED IN  SRB
                EARLIER TAPES. FIRST TARGET TO BE RETREIVED,
                TAPE 008 AND 035

 ** TAPE NUMBER   : 077

 * SOURCE OF TAPE : FIXED VIDEO, CONTACT #55
                THIN SKINNED STRUCTURE WITH RIBS, CANNOT       SRB
                IDENTIFY
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                              UNDERWATER VIDEO LOG

POSITION   DESCRIPTION                                     ORBITER    TARGET
                                                           SYSTEM     NUMBER


** TAPE NUMBER    : 078

* SOURCE OF TAPE : PAN & TILT, CONTACT #55
           SAME AS 077, THIN SKINNED STRUCTURE WITH        SRB
           RIBS, CANNOT IDENTIFY

** TAPE NUMBER    : 079

* SOURCE OF TAPE : NR-1, TAPE #12, OTV 54
                                                           SRB
                                                           SRB
                                                           SRB
1060       6' LONG GLASS PHENOLIC STRIF                    SRB
1085       55 GAL DRUM                                     SRB
2023       PHENOLIC AND CARBON STRIP                       SRB
2451       1 FT DIA PIPE ELBOW, 8 FT LONG                  SRB
2520       90 DEGREE ARC, 12' LONG WHITE RING, POSSIBLE    SRB
           STIFFENER RIB ON FWD SKIRT
2600       90 DEGREE ARC OF CLEAN WHITE METAL.. POSSIBLE   SRB
           INVER RING SECTION FROM FWD SKIRT
445        4 FT LONG BY 1 FT WIDE PHENOLIC AND CARBON      SRB
           STRIP
825        TWO PHENOLIC & CARBON STRIPS, 2 TO 3 FT LONG    SRB
860        60 ARCH RING 6" BY 10' TO 12' LONG              SRB

** TAPE NUMBER    : 081

* SOURCE OF TAPE : DEEP DRONE DIVE #32 & 33, OOC #3 & OOC #4, P&T
ALL        SAME DIVE AS TAPE #82                           SRB


** TAPE NUMBER    : 082

* SOURCE OF TAPE : DEEP DRONE, DIVE #32 & 33, OOC #3 AND OOC #4, FIXED
710        METAL SKIN, 2 FT X 1 1/2 FT, TORN EDGES,        SRB
           REINFORCED RIBS ON BACK SIDE OF SKIN

** TAPE NUMBER    : 083

* SOURCE OF TAPE : DEEP DRONE, CONTACT # 8 & 9, FIXED
ALL        MISCELLANEOUS SRB DEBRIS                        SRB

** TAPE NUMBER    : 085

* SOURCE OF TAPE : JSL DIVE #1265, TAPE J7, CONTACT #11 PINGER
010        CONTACT 11, THIS IS REPEAT OF SAME CONTACT -    SRB
           PINGER SET FOR LOCATION PURPOSES
ALL        AFT SRB SEGMENT                                 SRB
ALL        FIND #301-1, 9' X 14' SRB CASE SEGMENT 43 PIN   SRB
           HOLES (APPROX) ON THE TANG END

** TAPE NUMBER      086

* SOURCE OF TAPE : CYLINDER/D1277, TAPE J8, CONTACT #301-1
ALL        AFT SRB SEGMENT                                 SRB
ALL        SECTION OF SRM CASE SEGMENT APPEARS TO HAVE     SRB
           STRESS RELIEF, FLAP ON TANG END.  CONTAINS
           SOME PROPELLANT (UP TO 3 INCH THICKNESS)
ALL        ONE SIDE APPEARS TO BE SYSTEMS TUNNEL AREA      SRB
           WITH STRAIGHT LINE CUT PRODUCED BY RANGE
           DESTRUCT SYSTEM.  APPROXIMATELY 43 TANG HOLES
           (86 ARC SECTION.
ALL        HAS FIELD JOINT - APPEARS TO HAVE OUTER LEG     SRB
           OF CLEVIS BROKEN OFF ON END.  PART IS 14 FT
           LONG, 9-10 FT WIDTH.  NO POSITIVE ID AS TO RH
           OR LH.
ALL        BASED ON PREDICTED BURNBACK PATTERN PART        SRB
           APPEARS TO BE FROM FWD SEGMENT CYL

** TAPE NUMBER    : 087

* SOURCE OF TAPE : DEEP DRONE, FIX, DIVE #39-41, CONTACT 23-214
ALL        SUSPECT SRB DEBRIS, VIDEO NOT CLEAR, SUSPECT    SRB
           PIECE IS 4' HIGH BY 6' LONG

** TAPE NUMBER    : 089

* SOURCE OF TAPE : JSL II, DIVE 1279, CASE SEGMENT, SRB INHIBITOR
ALL        AFT SRB SEGMENT                                 SRB


** TAPE NUMBER    : 090

* SOURCE OF TAPE : JSL II, J-10-1, DIVE #1281, CONTACT #195, CYLINDER CASE
ALL        AFT SRB SEGMENT                                 SRB

** TAPE NUMBER    : 091

* SOURCE OF TAPE : JSL II, J-10-2, DIVE 1281, CONTACT #195, CYLINDER CASE
ALL        AFT SRB SEGMENT                                 SRB
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UNDERWATER VIDEO LOG

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POSITION     DESCRIPTION                                  ORBITER     TARGET
                                                          SYSTEM      NUMBER

** TAPE NUMBER   : 104

* SOURCE OF TAPE : JSL II DIVE 1287, CONTACT #538
ALL          NO ET IDENTIFIED                             SRB
ALL          NO IDENTIFIABLE ORBITER                      SRB
ALL          NO TDRS                                      SRB

** TAPE NUMBER   : 105

* SOURCE OF TAPE : DEEP DRONE P&T, TGT 325 & 215
0001         SRB CYLINDER SEGMENT APPROX 90 DEGREE ARC.   SRB
             NO OUTER LEG OF CLEVIS SEEN. ONLY INNER LEG
             REMAINS.  NO TANG.

** TAPE NUMBER   : 106

* SOURCE OF TAPE : DEEP DRONE FIX TGT 325 & 215
0            POSSIBLE SRM - VIDEO RESOLUTION NOT CLEAR    SRB
             ENOUGH TO IDENTIFY
460-1600     PROBABLE SRM - FACTORY JOINT CLEVIS WITH     SRB
             OUTER LEG GONE

** TAPE NUMBER   : 107

* SOURCE OF TAPE : JSL II, TAPE J12, CONTACT #502, DIVE 1288
             SRB SEGMENT, APPROX 90 DEGREE.  SEGMENT      SRB
             RIPPED AT LEAK CHECKPORT ON TANG ZERO
             DEGREES.  LSC CUT AT 90 DEGREE.  NO SIGN OF
             CLEVIS AT THE OTHER END

* SOURCE OF TAPE : JSL II TAPE J12, CONTACT #502, DIVE 1288
ALL          SRB SEGMENT APPROX 90 DEGREE.  SEGMENT RIPPED SRB
             AT LEAK CHECK PORT ON TANG ZERO DEGREES.  LSC
             CUT AT 90 DEGREE.  NO SIGN OF CLEVIS AT OTHER
             END.

** TAPE NUMBER   : 108

* SOURCE OF TAPE : JSL II DIVE 1287, CONTACT 538, J11
ALL          FWD SKIRT - PARACHUTES                       SRB

** TAPE NUMBER   : 109

* SOURCE OF TAPE : JSL II DIVE 1289, TGT 497, J12
001          RIGHT FRUSTRUM SEPARATION MOTORS WITH        SRB
             FRUSTRUM SKIN
ALL          FWD BOOSTER SEPARATION MOTORS & STRUCTURAL   SRB
             BOX

** TAPE NUMBER   : 110

* SOURCE OF TAPE : JSL II DIVE 1289, TGT 497, J13
001          RIGHT SRB SNUB RING WITH PARACHUTE LINES     SRB
             ATTACHED

** TAPE NUMBER   : 114

* SOURCE OF TAPE : JSL2 DIVE #1294, TARGET 615-2
ALL          SRM DEBRIS, FIELD JOINT CUT AT THE SYS       SRB         615
             TUNNEL, MOST OF CLEVIS OUTER LEG REMOVED.
             TRACES OF VACUUM PUTTY ON JOINT. NO TANG. 2-3
             INCHES OF PROPELLANT IN VARIOUS LOCATIONS ON
             SEGMENT

** TAPE NUMBER   : 115

* SOURCE OF TAPE : JSL1 DIVE 1274, TARGET 503-1
ALL          FWD DOME WITH IGNITER, 619 FEET DEPTH        SRB         503

** TAPE NUMBER   : 116

* SOURCE OF TAPE : JSL1 DIVE 1724, TARGET 504-1 AND 504-2
ALL          TARGET 504-1 AFT SKIRT OUTER DIA WITH SOME OF SRB        504
             PART NUMBER VISIBLE ????-0125-002 - TARGET
             504-2 APPEARS TO BE AFT SKIRT CLEVIS JOINT

** TAPE NUMBER   : 118

* SOURCE OF TAPE : JSL I, DIVE 1278, OTV 99, OOC 517
ALL          AFT NOZZLE CARBON WRAP.  COMPLETE 360 BY     SRB
             APPROX 36" HIGH

** TAPE NUMBER   : 119

* SOURCE OF TAPE : JSL I DIVE #1731, TARGET #579
ALL          SRM ETA SEGMENT.  APPROX 3' OF CLEVIS.  NO   SRB
             VISIBLE REMAINS OF CLEVIS OUTER LEG.
             INHIBITOR ABOUT 12' HIGH.  1 1/2 TO 2"
             PROPELLANT UNIFORMALLY DECREASING TO ABOUT 1
             INCH AT TANG END
ALL          BOTH ETA STUBS IN PLACE. HOLES ON THE STUBS - SRB
             ARE ECCENTRIC AND SIGNS OF SOOT IN STAB AREA.
             PIECE OF ET TRANSITION STILL ATTACHED TO STUB
```

UNDERWATER VIDEO LOG

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POSITION   DESCRIPTION                                      ORBITER     TARGET
                                                            SYSTEM      NUMBER


** TAPE NUMBER   : 121

* SOURCE OF TAPE : JSL I, DIVE #1730, CONTACT #21 (1 OF 2)
0-130        SRB AFT SEGMENT CASE PANT TARGET ADDENDUM #XI SRB
130          ADDENDUM X (21-5) TARGET                       SRB
250          ADDENDUM XVI                                   SRB

** TAPE NUMBER   : 122

* SOURCE OF TAPE : JSL I, DIVE #1730, CONTACT #21 (2 OF 2)
                                                            SRB
0-215        INSTALLATION OF SNAP SHACKLES ON 21-9,         SRB
             ADDENDUM XVI
215          TARGET 21-5, ATTEMTP TO INSTALL THREADED       SRB
             SHACKLES
360          TARGET 21-2, ADDENDUM II                       SRB
340          SMALL PIECE, UNKNOWN                           SRB

** TAPE NUMBER   : 126

* SOURCE OF TAPE : NR-1, TAPE 14B
001-550      SRM DEBRIS, CLEVIS FIELD JOINT WITH 6" OF      SRB
             INHIBITOR IN PLACE ABOUT 8' OF JOINT VISIBLE
             OUT OF OCEAN BOTTOM. OUTER LEG OF CLEVIS IS
             BROKEN OFF.  NO PROTUSIONS. LOC. 28 43.68N,
             79 3
2430         SRM DEBRIS CLEVIS ABOUT 50" CIRCUMFERENCE, 8' SRB
             OD, 458 FT FEPTH
550-660      DOME WITH IGNITER                              SRB
830          DIA 14' NOZZLE RING (PHENOLIC)                 SRB

** TAPE NUMBER   : 127

* SOURCE OF TAPE : NR-1, TAPE 15
0-800        8' X 10' PIECE OF SRM CASE FRAGMENT -          SRB
             POSSIBLE CLEVIS END
1325         LARGE PIECE OF SRB CASE                        SRB
2400         LARGE PIECE (180 DEGREE, PLUS) OF CASE         SRB
3150         LARGE PIECE OF SRB CASE                        SRB
4250         SRM CASE JOINT                                 SRB
4800         UNKNOWN PIECE OF METAL STRUCTURE               SRB
4950         TRIANGULAR SHAPED PIECE OF UNKNOWN ORIGIN,     SRB
             SMALL
4984         UNKNOWN ORIGIN METAL, MIGHT BE SRM             SRB
5150         RING, MAYBE ET ATTACH                          SRB
5400         CLEVIS END OF SRM CASE                         SRB


** TAPE NUMBER   : 128 .

* SOURCE OF TAPE : NR-1, TAPE 16
0-440        PROPELLANT FIELD                               SRB
1430         SRM SKIN WITH PROPELLANT, NR-1 OBSERVER        SRB
             GUESSED 2 1/2' X 1'
1690         8' X 12' SRM CASE FRAGMENT TANG                SRB
440          6' X 4' SRM CASE FRAGMENT, 28-30 TANG HOLES    SRB

** TAPE NUMBER   : 129

* SOURCE OF TAPE : JSL I, DIVE #1736, OOC #502
ALL          ATTACHING LIFTING HARDWARE TO CONTACT 502      SRB

** TAPE NUMBER   : 130

* SOURCE OF TAPE : JSL II, DIVE #1307, OOC #615, J21
ALL          ATTACHING LIFTING HARDWARE TO 615-3, 615-1A    SRB
             AND 615-1B

** TAPE NUMBER   : 131

* SOURCE OF TAPE : JSL I, DIVE #1737, TGT 538 (1 OF 2)
ALL          FWD SKIRT                                      SRB

** TAPE NUMBER   : 132

* SOURCE OF TAPE : JSL I, DIVE #1737, TGT 538 (1 OF 2)
ALL          ELECTRICAL PANELS FROM THE FWD SKIRT OF 538    SRB
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                          UNDERWATER VIDEO LOG

POSITION    DESCRIPTION                                   ORBITER     TARGET
                                                          SYSTEM      NUMBER

** TAPE NUMBER   : 133

* SOURCE OF TAPE : NR-1, TAPE #17
1150        RUDDER FROM SHIP                              SRB
1263        SRM CASE FRAGMENT 8' X 10' TANG & CLEVIS END  SRB
1740        SRM CASE FRAGMENT, RING - 160 ARC - CLEVIS    SRB
            END - 6"-8" HEIGHT
2035        CANNOT IDENTIFY BY TAPE, SHIP OBSERVER ON     SRB
            BOARD SAYS PIECE LOOKS OLD AND NOT SHUTTLE.
            CORAL GROWTH
2127        NON SRM                                       SRB
2200        NON SRM                                       SRB
280         SRM CASE FRAGMENT, 4' X 3'                    SRB
30          SMALL PIECES OF NOZZLE/CASE SCATTERED ALONG   SRB
            NORTHERLY DIRECTION FROM #24
524         NEW HYDRAZINE BOTTLE                          SRB
767         SRM CASE FRAGMENT, HAS PROPELLANT, SMALL      SRB
            PIECE 2 1/2' X 2 1/2'

** TAPE NUMBER   : 134

* SOURCE OF TAPE : JSL II, DIVE #1308, OOC #631, J22
ALL         CASE SKIN W/PROPELLANT, APPEARS TO HAVE       SRB
            CLEVIS AT BOTH ENDS, NO BURN MARKS OR SCORCH
            MARKS NOTED, ATTACHED SHACKLE FOR RETRIEVAL
            AND PINGER, ONE END HAS O-RING GROOVES
ALL         CASE FRAGMENT W/PROPELLANT.  ATTACHING        SRB
            LIFTING HARDWARE

** TAPE NUMBER   : 135

* SOURCE OF TAPE : JSL I, DIVE #1739, TGT #131
ALL         ATTACHING LIFTING HARDWARE                    SRB

** TAPE NUMBER   : 136

* SOURCE OF TAPE : JSL I, DIVE #1740, TGT 524 (PART I)
ALL         FWD DOME - ATTACHING LIFTING HARDWARE         SRB
ALL         ATTACHING LIFTING HARDWARE                    SRB
ALL         CONTACT 5038, CASE FRAG W/CLEVIS, 5039, CASE  SRB
            CYLINDER W/TANG, 5126 CASE FRAGMENT, 5128,
            CASE FRAGMENT W/TANG

** TAPE NUMBER   : 139

* SOURCE OF TAPE : JSL II, DIVE #1311, OOC #5038, J24
ALL         ATTACHING LIFTING HARDWARE                    SRB

** TAPE NUMBER   : 140

* SOURCE OF TAPE : JSL II, DIVE #1311, OOC #5038, J25
ALL         ATTACHING AND VERIFYING LIFTING HARDWARE      SRB
ALL         CASE FRAGMENT W/CLEVIS                        SRB
ALL         STRUT ATTACHED TO ET AND SRB ATTACH RING      SRB
            (ATTACHING LIFTING HARDWARE)

** TAPE NUMBER   : 143

* SOURCE OF TAPE : JSL I, DIVE #1741, TGT #635
ALL         ATTACHING LIFTING HARDWARE                    SRB

** TAPE NUMBER   : 144

* SOURCE OF TAPE : JSL I, DIVE #1742, TGT #468
ALL         CASE FRAGMENT W/TANG                          SRB

** TAPE NUMBER   : 145

* SOURCE OF TAPE : JSL II DIVE #1314, J27, OOC #5126-1, 5126-2
ALL         ATTACHING LIFTING HARDWARE, CONTACT 5126-2    SRB


** TAPE NUMBER   : 148

* SOURCE OF TAPE : JSL I, DIVE #1746, CONTACT #699
ALL         CASE FRAGMENT W/CLEVIS (ATTACHING LIFTING     SRB
            HARDWARE)

** TAPE NUMBER   : 149

* SOURCE OF TAPE : JSL I DIVE #1755, SRB MOTOR CASING
ALL         3'X4' PIECE OR SRM FRAGMENT WITH 11"-12"      SRB
            INHIBITOR - NO ATTACH RING STUBS
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APPENDIX B

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

ADDENDUM NO. I
(R.H. SRB AFT SEG/DOME/STIFFENER SEG)
TO
REQUIREMENTS FOR 51-L SRB RETRIEVAL OPERATIONS
March 6, 1986

Authorization for Implementation

Approval: ______________________________
Edward A. O'Connor, Jr.
Colonel, USAF
NASA STS 51L Data and
Design Analysis
Task Force

____
Richard H. Truly
Chairman, STS 51L Data and Design
Analysis Task Force

Concurrence:

____
A. A. McCool
Marshall Space Flight Center

C. T. Mullen
Eastport International

____
James Buckingham
Commander, USN
Supervisor of Salvage

Addendum No. 1

1.0 *Purpose*—This addendum defines hardware to be retrieved in accordance with requirements as defined in the base document entitled "Requirements for 51-L SRB Retrieval Operations" dated March 6, 1986. The hardware identification and other data/requirements are defined in the subsequent paragraphs.

2.0 *Identification of Hardware*—51-L Shuttle Element Right Hand SRB Aft Seg/Dome/Stiffener Seg(s) (including any O-rings or parts of O-rings or clevis joints that may be lying in vicinity of large articles).

3.0 *Priority*—High for Analysis—Part is section of R.H. aft segment which appears to be sooted and possibly heat affected by anomalous source. Laboratory analysis may ascertain source of external contamination and metallurgical properties to aid in flame source location.

4.0 *Location*—Side scan sonar contact #C0001; Lat. 28° 49' 32"N, Long. 79° 52' 40"W

—JSL II Contact 0001X, Dive #1245; Lat. 28° 49' 10" Long. 79° 52' 32"

5.0 *Retrieval Vessels*—Ship—Stena Workhorse
Submersible—Gemini

6.0 *Description of Hardware*—

a) A sketch(s) showing geometry, calculated weight, estimated center of gravity, and major dimensions is shown on the following pages.

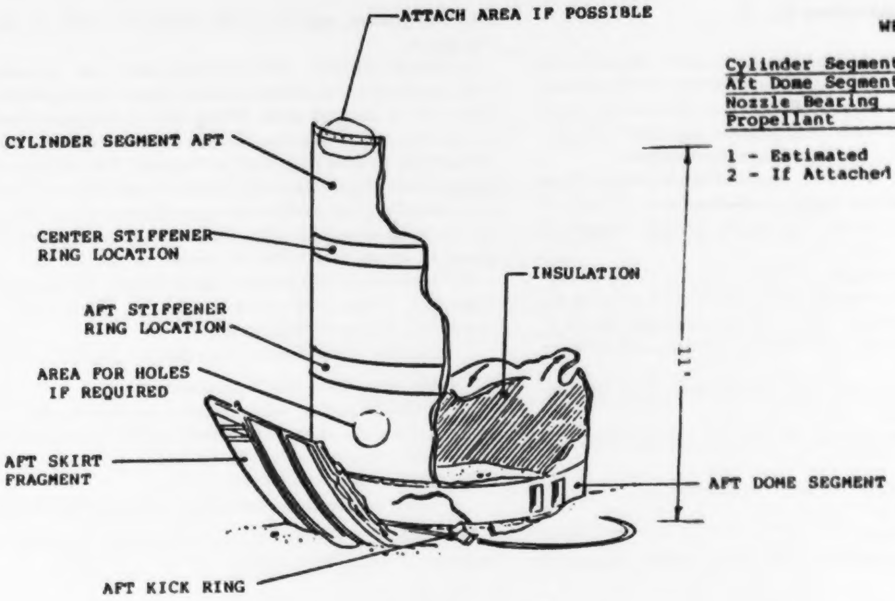
b) Attach Methods—Since no field joints (clevis containing O-rings/grooves) are apparent in video tapes or photographs of hardware, use of tang or clevis lifting tools is recommended if they can be connected. Gripping devices may be required. Use of thermal devices to burn holes may be required. Use of thermal devices to burn holes into case walls is discouraged due to need to perform metallurgical analysis for heat affected areas. This method should be used *only* as a last resort and if used, holes should be made as far aft as possible as shown on the sketch.

c) Photos of part for positive identification are enclosed. Video Tape #17, Frames 61-410 from JSL II, Dive #1245 may be referenced for more description.

d) Hazards (propellant, pyrotechnics, other)

- —No propellant has been observed.
- —If propellant or other hazards are found after closer examination, then further steps will be taken in accordance with requirements defined in the Appendix to the basic document.
- —Hardware contains insulation material with asbestos fibers.

7.0 *Timelines*—Estimated time from ship on location to parts on-deck—2 days (48 hours).

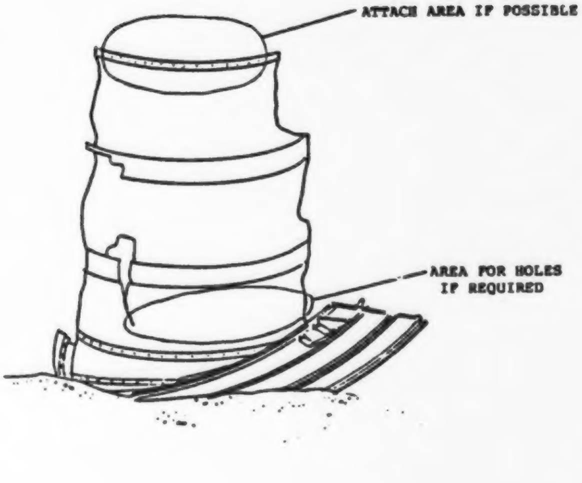

ATTACH AREA IF POSSIBLE
CYLINDER SEGMENT AFT
CENTER STIFFENER RING LOCATION
INSULATION
AFT STIFFENER RING LOCATION
11'
AREA FOR HOLES IF REQUIRED
AFT SKIRT FRAGMENT
APT DOME SEGMENT
AFT KICK RING

SIDE VIEW 1

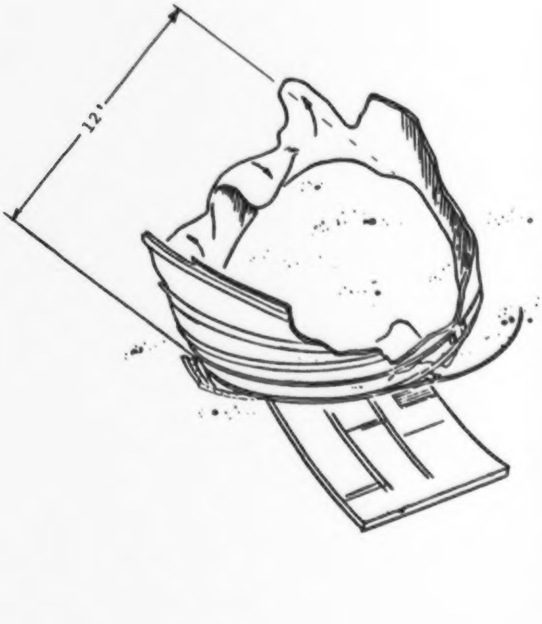
WEIGHTS

Cylinder Segment Aft	2800 lbs[1]
Aft Dome Segment	4964 lbs
Nozzle Bearing	3000 lbs[2]
Propellant	400 lbs[1]

1 - Estimated
2 - If Attached


ATTACH AREA IF POSSIBLE
AREA FOR HOLES IF REQUIRED

SIDE VIEW 2



TOP VIEW

Contact 21-1, Factory Joint

Contact 21-1, Kick Ring

APPENDIX C

BASIC

THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS PLAN FOR SRB SALVAGE OFF-LOAD AND TRANSPORT TO STORAGE FACILITY

March 6, 1986

Approved: ______________________________

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1.0 *Information:*

1.1 *General:* SRB hardware that has been retrieved from the ocean floor, and transported to the Trident Wharf South will be off-loaded and transported to Hangar O in accordance with requirements defined in this document.

1.1.1 *Changes:* Order of performance of operations specified in this plan may be altered providing change does not increase hazard level. ESMC and NASA Safety, and NASA Engineering support personnel will be on site to coordinate real time changes that may occur during the complex operations.

1.2 *Safety Requirements:* NASA Safety and Security will be the primary contact with ESMC Range Safety and Security for coordination of Port activities related to 51-L debris recovery.

1.2.1 All personnel will be made aware of any hazards, contraints, and cautions associated with the operation.

1.2.2. During hazardous lifting/handling operations only manloaded essential personnel will be permitted in controlled areas. Any increases in number of essential personnel requires approval of the operations Lead and ESMC/NASA Safety Representative or his designee.

1.2.3 Technicolor organization personnel will be on site prior to all handling, safing or processing activities for evidence documentation.

1.2.4 All cloths, gloves, booties, etc., that are used during handling or inspections will be placed in an approved container and identified as containing "Ammonium Perchlorate," and given to EOD personnel for removal to the EOD Range.

1.2.5 All cloths and protective equipment suspected to be contaminated with asbestos fibers will be placed in an approved container and identified as containing "possible asbestos," and given to Waste Disposal for disposal.

1.2.6 No task will start or, if in progress, will cease whenever an electrical storm is within 5 miles of the port/facility. Personnel will evacuate to a safe area until such time as the electrical storm passes.

1.2.7 For any special operational task (i.e. sampling, disposal etc.) on a component, a specific procedure will be written by the appropriate system engineer and approved by EOD, ESMC and NASA Safety and the Salvage Board representative.

1.2.8 Trident Wharf South Personnel: ESMC and NASA Safety will be on site. Pan Am ordnance personnel will be used to handle debris with propellant under EOD/Safety direction.

1.2.9 Hangar "O": A government safety representative or a designee will be on site when personnel are performing work and/or inspections.

1.2.10 Hazards: Hazards that may be encountered during the handling process are:

a. Ordnance—Detonators, igniters, squibs, super zip, etc.

b. Lifting and handling of loads of significant weight; equipment malfunction during lifting, lowering or positions of loads.

c. Possible exposure to propellant grain. (PBAN, AP, AL, Binder, ammonia smell.)

d. Possible exposure to asbestos fibers. (Ingredient in case insulation.)

e. Possible exposure to fractured (jagged) carbon cloth phenolic and/or carbon glass cloth phenolic.

f. Sharp metal points/edges.

g. Possible exposure to hydrazine. (Clear liquid, white vapor, ammonia smell.)

h. Possible exposure to a damaged battery. (Potassium hydroxide or dimethyl sulfite.)

1.2.11 Operating Procedures—Standard EOD and NASA operating procedures will be in effect throughout the off-loading and storage operation.

1.2.12 Only essential personnel as identified by Port and Hangar "O" manloading list will be permitted in controlled areas. NASA Operations Representative will provide the NASA manloading requirements.

1.2.13 No smoking, no open flame producing devices will be allowed in controlled areas.

1.2.14 Protective Clothing:

a. During handling operations of hardware containing propellant, personnel shall wear flame-retardant nonstatic-producing long-sleeved coveralls, and gloves.

b. Hard hats will be worn in controlled areas during lifting operations.

c. All personnel entering Hangar "O" will wear flame-retardant nonstatic producing long-sleeved coveralls. Shoes will not have taps or exposed metal. If entering propellant area, personnel will wear cloth booties over their shoes.

d. If Environmental Health determines that asbestos fiber hazards exist, personnel will wear an air purifier cartridge type respirator (Norton respirator with purple cartridge.)

1.2.15 Ordnance:

a. Thick pieces (slabs) of propellant, all ordnance components and other hazardous materials identified by ESMC/NASA Safety or EOD will be removed directly from the ship to the EOD Range for storage.

b. In the event any unexpended ordnance component is discovered EOD personnel will remove. If damage evaluation by EOD is found to be great enough, area will be cleared of all personnel with exception of EOD team who will remove damaged ordnance. Safety representatives will verify area is clear prior to start of ordnance removal.

c. Daily inspection of components will be performed by Pan Am Ordnance and EOD personnel for evidence of residual propellant. If propellant crystallization is found, EOD with the assistance of Pan Am ordnance personnel will remove with cloths moistened with water. Cloths will be placed in an approved container and removed by EOD to the EOD Range.

1.2.16 Lifting Hazards:

a. Controlled areas shall be identified and implemented during all lifts.

b. Essential personnel during hoisting operations will be determined real time by Safety personnel.

c. All "hands on" personnel directly involved with the lift will wear protective clothing (coveralls and gloves, air purifier cartridge if doing rigging in dumpster).

d. Ensure lifting devices do not damage ordnance items during lift.

e. Tag lines will be used when load is lifted beyond arm's reach.

f. Ground straps will be used, when possible, on all lifts.

g. Lifting operations when hardware contains propellant shall not be performed without authorization by EOD personnel and the ship's Captain if the ship is involved.

h. Resolution of Conflicts: The EOD representative will coordinate with the Salvage/Recovery Safety Team to resolve any lifting/operational conflicts.

1.2.17 Toxic Chemical Safety:

a. The possibility of potassium hydroxide or dimethyl sulfite solution presence from a damaged battery exists in forward skirt. If detected, solution(s) must be neutralized and gases purged. EOD personnel will store all batteries at the EOD Range.

b. Hydrazine: Handle all hardware as if it is contaminated. All pressure vessels that may contain hydrazine will be taken directly to the EOD Range for verification of safe condition. Wear gloves.

1.2.18 Asbestos:

a. Environmental Health will perform visual and surface assessments to identify health concerns for employees handling hardware. Protective clothing/equipment (gloves, coverall, air purifier cartridge respirator) will be worn during off-loading of dumpster and at any other time as directed by E.H. and Safety.

2.0 *Pre-Operation Preparations:*

2.1 *Ship Activities:* Prior to arrival at Port the propellant container (dumpster) will be drained and covered with a damp canvas.

CAUTION: Do not use plastic.

NOTE: Insuring propellant stays wet will mitigate the build up of static electricity.

2.2 *Port Activities:* Setup and operation of GSE and facility required to perform this task will be performed prior to arrival of ship at Port.

a. Establish control area as directed by ESMC/NASA Safety. (Approximately 500 feet—each end of dock.)

b. Verify required support on site.

c. Trucks and/or pallets will be covered with Orcofilm, AN-22 or equivalent.

d. Trucks will be verified to be in good condition; i.e., brakes, exhaust system, two fire extinguishers, and if applicable, 5th wheel connection. Trucks to carry parts containing propellant will display "Explosive B" placards on all four sides of vehicle.

e. Cape Support will verify that all lifting/hoisting equipment is adequate for handling the maximum expected load, and operators are certified.

f. Clear entire control area of all static-producing or nonconductive plastic sheet materials, debris, and equipment which is not required to support operation.

2.3 *Arrangement/Lifting Equipment:* Equipment/tools to be used for attachment and for lifting components from the dumpster will be identified. Particular care shall be given to protecting case field joint areas and seals from damage.

3.0 *Component Removal From Ship:*

NOTE

During hazardous lifting/handling operations, a controlled area will be established by safety based on level of hazard and implemented by NASA Operations Lead. Only manloaded essential personnel will be permitted in the area. Any increase in the number of essential personnel requires approval of the NASA Operations Lead and the ESMC/NASA Safety representative or his designee. Essential personnel are as follows:

Essential Personnel	*Preparations*	*Hazardous Operations*
Pan Am Ordnance	4	4
ESMC Safety (Lead for Safety)	1	1
Pad Safety (with NASA Ops Lead)	1	—
NASA Safety (spport to ESMC Safety)	1	1
Dock Master	1	—
Pan Am Heavy Drivers	2	—
EOD	2	2(+2 on ship)
Environmental Health	1	—
NASA Operations	2	—
NASA Engineers	2	—
Technicolor Photographer	1	1

3.1 *Hoisting Preparations*—Perform as follows:

3.1.1 When ship has docked, the first personnel on board will be a team consisting of the following personnel:

1 ESMC Safety
1 NASA Safety
2 EOD
1 Environmental Health
1 Ops Lead (if required)

3.1.2 EOD Representative will verify all explosive ordnance and loose propellant is in a safe condition prior to the full Team inspection of the recovered components, and in an approved container for removal to the EOD Range.

3.1.3 Environmental Health will perform visual and surface assessment to identify health concerns for employees handling the materials.

3.1.4 Safety will ensure all debris is checked by EOD and Environmental Health prior to release for off-loading or review by other personnel.

3.1.5 After preliminary condition of debris is determined, EOD/Safety with assistance as required of Ordnance Engineer, or his designee will review the debris for possible propellant crystallization and any other previously unidentified ordance component. NASA/ESMC Safety will brief NASA Operations Lead on handling and rendering safe.

NOTE

If propellant crystallization is found, EOD with the assistance of Pan Am ordnance personnel will remove with cloths moistened with water, and place in an approved container for removal to the EOD Range.

EOD will apply a light coat of hydraulic fluid if required for safing.

If ordnance components are found, EOD will remove and transport to EOD Range.

3.2 *Hoisting Operations:*

3.2.1 The ship's crane will be used when possible.

3.2.2 Establish an area for debris to be off-loaded.

3.2.3 Off load propellant container (dumpster) to dock.

WARNING

Due to possible exposure to asbestos fibers, personnel required to enter the dumpster for rigging connections must wear an air purifier cartridge type respirator (Norton respirator with purple cartridge), or equivalent.

3.2.4 Off-load debris from propellant container (dumpster) directly to truck and place on a pallet that is covered with Orcofilm, AN-22, or equivalent.

3.2.5 Under direction of EOD, Pan Am ordnance personnel will wipe hardware with damp cloths to remove excess water and any possible AP that was not accessible during initial ship board inspection.

NOTE

All water removed and cloths that are used will be placed in an approved container and identified as containing "ammonium perchlorate," and given to EOD personnel for removal to the EOD Range.

3.2.6 If initial offload isn't directly to truck after debris has been wiped, lift using dock side crane and position onto pallet covered with Orcofilm, AN-22 and load onto truck.

3.2.7 Secure load—Cushion with sand bags, tie down, and cover with tarp.

NOTE

If tie down straps must be used across propellant, sand bags or an equivalent approved softener must be used.

3.2.8. If propellant is on debris, truck(s) will be escorted to Hangar O by Security, ESCM/NASA Safety and EOD.

3.2.9 If no propellant is on debris, truck(s) will be escorted to Hangar O by security and a NASA Representative.

4.0 *Component Removal From Truck To Hangar "O"*

NOTE

During hazardous lifting/handling operations only essential personnel as specified will be permitted in controlled area. Any increase in number of essential personnel requires approval of Government safety representative or his designee.

4.1 *Hoisting Preparations:*

4.1.1 Clear Area of Non-essential personnel. (Approximately 50 feet around truck.)

4.1.2 Verify all personnel have proper protective clothing.

4.1.3 Verify certification of hoisting equipment and operators.

4.2 *Handling Operations*—Perform as follows:

4.2.1. Debris will remain on pallets.

4.2.2 Crane or forklift will remove pallets from truck and position in Hangar O as directed by NASA Representative.

4.2.3 Components that contain propellant will be stored separate from other components.

4.2.4 Components that contain propellant will be grounded to facility ground, if possible.

4.2.5 After debris is positioned in Hangar, EOD Representative will apply a light film of hydraulic fluid on propellant to reduce propellant drying.

4.2.6 Environmental Health will perform periodic assessments based on monitoring data and proposed SRB inspection activities to determine hazard potential and personal protective equipment requirements. As a minimum, the storage site will be inspected at least once every 24 hours, unless inspection warrants downgrade.

4.2.7 Identification and accountability of debris will be performed in accordance with the Impound Area Operation Plan.

4.2.8 Personnel controls and facility operations will be performed in accordance with the Hangar O Operations Plan.

5.0 *Documentation:* A log of events referenced to date and time shall be maintained. Difficulties encountered, hardware damage incurred during handling, and other pertinent data will be recorded. The log should be a continuation of documentation received from the ship at turnover of hardware on dock. The log shall be the responsibility of the NASA Operations Lead.

6.0 *Responsibilities:*

6.1 *NASA Operations Lead:*

a. Directs dock operations for compliance with operating instructions as defined in this document.

b. Coordinates KSC support on site and interfaces with the ETR Lead for realtime requirements.

c. Acts as the primary operations point of contact between other agencies such as Range, DDMS, and SUPSAL.

d. Has final access authority for KSC personnel required for dock operations and coordinates these requirements with the proper ETR contact.

e. Provides status to impound area and provides Lead NASA representation during movement from dock to impound area.

f. Handles the transfer of components from the EOD hazardous storage area to the impound area.

6.2 *NASA Engineering:*

a. Provides the system engineering expertise as required to verify and assist EOD in hazard identification and safing.

b. Provides a Lead Engineer to monitor hardware processing and serve as a single point of contact to the Operations Lead.

c. Ensures compliance with applicable corrosion control plans for electronic devices and metals.

6.3 *Safety:*

a. The EOD Team will have authority to direct all operations involving ordnance or hazardous materials in coordination with the Safety/Operations Lead if time permits.

b. Advises EOD and Environmental Health on possible component hazards.

c. Verifies that components have been properly checked for hazards prior to transport to impound area.

d. Monitors those components which are moved to the EOD hazardous storage area and advises NASA Operations Lead when they may be moved to the impound area.

e. Interface with the NASA Operations Lead for personnel access requirements at the dock area.

f. NASA Safety shall be responsible for ensuring that components are handled in a manner to preserve evidence.

6.4 *Security:*

a. Provides the security expertise as required.

b. Review components for sensitive items and remove those items as required. Advise NASA Operations Lead of items removed to be noted on manifest.

c. Verify proper security support is being provided to operations personnel at the dock and during transportation to impound area.

7.0 *Emergency Instructions:*

7.1 *General Instructions:*

Safety Personnel and EOD will coordinate emergency actions in the work area.

7.2 *Personnel Injury:*

Immediately request medical assistance and advise of nature of injury and location of accident.

7.3 *Fire:*

Clear area of all personnel. Contact fire immediately.

7.4 *Equipment Failure:*

If abnormal noise or visual observation indicates possible lift/handling equipment failure; stop lift operation, secure load and clear all personnel from the controlled area. EOD, Safety and supporting personnel will review situation to determine how to proceed with operation.

APPENDIX D
THIS DOCUMENT CONTAINS HAZARDOUS OPERATIONS

PLAN FOR
PROPELLANT DISPOSAL
FOR 51-L SRB COMPONENTS

March 28, 1986

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Figure 1 Identifies: The part, contact number, approximate weight of propellant, safety clearance area, and location of the ignition set-up O-356
Figure 2 Identifies: The area of the part to be protected by vacuum putty, locations for installation of temperature indicators, where metal hardness tests should be taken, and the areas where water is to be be sprayed on the metal side of the segment O-356

1.0 *DESCRIPTION*

1.1 *Scope*—This document defines hardware from which propellant is to be removed for investigative reasons, the requirements for safe removal of propellant and preservation of desired evidence, and approval for the removal.

1.1.2 This procedure will be performed only at the Eastern Space and Missile Center (ESMC) Explosive Ordnance Disposal (EOD) Range.

1.1.3 Order of operations specified in this plan may be altered providing change does not increase hazard level.

1.2 *Applicable Documents and Figures*—The following list of documents of the issue in effect on the date of publication and figures form a part of this procedure to the extent specified herein.

1.2.1 DOCUMENTS

EOD Standards, as outlined in 60 Series Tech Orders
ESMC 127-1, Range Safety Manual

> NOTE: Prior to the implementation of this plan, figures for the specific component must be attached. The figures must contain the following information. This plan is not complete without the attached figures.

1.2.2 FIGURES

Figure 1—Identifies: The part, contact number, approximate weight of propellant, safety clearance area, and location of the ignition set-up.

Figure 2—Identifies: Area of part to be protected by vacuum putty, locations for installation of temperature indicators, where metal hardness tests should be taken, and the areas where water is to be sprayed on the metal side of the segment.

2.0 *SAFETY INFORMATION*

2.1 *General Information and Background*

The solid propellant being recovered from the ocean floor is being found in two configurations:

a. Loose bulk propellant, some of which is badly damaged with cracks and porosity, and ranges in size from a few cubic inches to approximately 1 cubic foot. This material has been recovered from depths from 100-300 feet of water. When the water-soaked propellant dries, it exhibits ammonium perchlorate (AP) crystals. The AP that is contaminated with iron and organics is pinkish or yellow in color and the uncontaminated is white or clear in color.

b. The majority of propellant recovered is attached to large pieces of insulated Solid Rocket Motor (SRM) steel case. In most cases, this propellant is in the form of slabs attached to the liner and insulation on the steel case and varies in thickness from less than inch ¼ up to 3 or 4 inches. In general, the propellant is on the inside surface of the steel case and is sheared off of the case in the failure areas. The edges of the propellant are damaged with cracks and porosity, while the areas away from the failure edges of the case seem to be in relatively good condition. AP is also leaching as the propellant dries out and both contaminated and uncontaminated AP as described above are in evidence. The weight of the propellant attached to individual pieces of broken up case segments varies on the average from a few hundred pounds to a thousand pounds.

2.2 *Safety Hazards*

The hazards associated with this propellant are those associated with Polybutadiene Acrylonitrile (PBAN) propellant with the additional hazards listed herein.

a. The propellant is damaged and cracked and has been subjected to sea water for over one month at depths ranging from 100 to 1200 feet, and as such, is porous and has absorbed sea water. In the damaged and cracked areas, the sea water has penetrated the total depth of propellant as verified by visual examination of some damaged propellant. In the undamaged propellant, the sea water penetration is limited to no more than ½ inch. The porosity, in combination with the leaching of AP, may increase the sensitivity to shock and/or friction ignition. It may also increase the probability of a transition from burning to detonation (Deflagration—Detonation Transition (DDT)).

> NOTE: The DDT has been experienced in other composite propellants that were recovered form the ocean and later disposed of. Examples are Minuteman, Polaris, and Poseidon propellants.

b. The AP leaching from the propellant has been contaminated with ferric oxide, organic materials, and other materials which probably have increased its sensitivity to shock and ignition. Studies conducted by the Air Force Rocket Propulsion Laboratory (AFRPL) indicate that foreign materials significantly increase the sensitivity of composite AP propellants. Examples are iron oxide, sand, wood, nylon, and phenolics.

c. The SRM segment liner and insulation contains asbestos which may present a hazard if the propellant/liner is allowed to dry.

2.3 *Safety Precautions*

The following precautions shall be implemented for this propellant.

1. Keep wet.
2. Do not permit shear between hard surfaces.
3. Do not subject to direct heat/flame.
4. Do not shock (no drops).
5. AP will leach out—keep in water or soak down.
6. Use sand bags or wood pallets to secure or brace while handling the segments of steel and propellant.
7. Do not place pieces of propellant in contact with each other except during and just prior to actual disposal operation.
8. Loose propellant should not be placed in contact with or on any case segment with propellant attached.
9. Store loose propellant in an approved container.
10. Propellant sensitivity is a function of thickness and porosity following sustained exposure to water. Thin pieces are likely to explode.
11. Do not handle AP crystals and insure that crystal areas are wetted down prior to movement of any propellant.
12. Keep broken steel case segments with propellant attached on handling pallets for all movement and use a forklift or approved crane to handle or move pallets.
13. Disposal operations will be conducted using safety clearance zones that assume a detonation of the propellant and provide adequate protection from blast overpressure and fragmentation (each part will have a distance assigned, see Figure 1).
14. All other explosives on the range will be isolated by the berm. SRB parts with exposed solid propellant will be wetted prior to all burns.
15. EOD team will initiate ordnance from their bunker with all other personnel located in a safety fallback area, clear from the part that is being burned as well as all other stored explosives.
16. All handling/lifting of parts will be performed by EOD/Pan Am ordnance personnel.
17. No operation will commence or continue if an electrical storm is within 5 miles of EOD Range or wind speed at the surface is 15 knots or higher from the East. All personnel will evacuate Range during adverse weather.

3.0 *REQUIREMENTS*

During hazardous lifting/handling operations, a controlled area will be established and implemented by EOD based on level of hazard. Only man-loaded essential personnel will be permitted in the area. Any increase in the number of essential personnel requires approval of the ESMC/NASA Safety representative or his designee. EOD will be responsible for control of access to the range. One EOD member will be at the gate at all times. Essential personnel are as follows:

Essential Personnel	*Preparations (Hazardous Operations)*	*Set Up and Initiation*
Pan Am Ordnance	4	0
ESMC Safety	1 as required	0
KSC Safety	1 (1 additional if required)	0
EOD	4	3
Environmental Health	2	0
NASA MSFC Engineer	2	0
NASA KSC Operations Engineer	1	0
Technicolor Photographer	2	1
Morton Thiokol, Inc.	1	0
NTSB	1	0
Pan Am Water Crew	3	0
NASA DE Engineer	1	0

WARNING

> THE OPERATIONS IN THIS PROCEDURE ARE CONSIDERED HAZARDOUS BECAUSE OF PRESENCE OF LIVE PROPELLANT AND ASBESTOS.

3.1. *Pre- and Post-Operation Metal Hardness Tests*—The following will be performed prior to and after propellant disposal operations are completed. Documentation will be maintained by MSFC Engineer.

1. Remove surface contamination (AP corrosion, paint, TPS . . .). Approximate: 3 sq. inch on outboard steel surface as identified in Figure 2.
2. Wash area prior to sanding. Sand outboard steel surface with fine grit abrasive paper. Calibrate Newage Portable Hardness Tester with calibration blocks.
3. Take an average of three hardness readings per location and record for data analysis.

3.2 *Propellant Disposal Operations*

The purpose of disposal is to remove all the remaining propellant from the steel case segments and dispose of the bulk propellant without causing explosions. The procedure to be used for burning the propellant is as follows.

a. The part will be wetted down with water prior to movement and all exposed AP areas will be soaked to dissolve the AP or wash it off.

b. The part will be moved to the burn area to the East of the sand berm and be oriented so that the tang end is seaward. After move is completed, other personnel required for preparation may return to area. Essential personnel for move will be:

EOD—2
Pan Am Ordnance—3

c. The part will remain on its handling pallet and be burned in this configuration.

d. Thermal protection will be implemented in accordance with paragraph 3.4 prior to burn. In addition, a metal hardness test will be performed by MSFC Engineer.

e. Perform checkout of water spray system.

f. An area at least 12 inches wide on the end opposite the tang will be soaked with diesel fuel. The remainder of the propellant area will be again sprayed with water just prior to ignition.

g. The appropriate number of M-14 thermite grenades will be placed on the propellant approximately 2 feet apart on the area that has been soaked with diesel fuel.

h. Standard EOD initiating procedures, as outlined in the 60 Series Tech Orders, will be used including remote initiation of the thermite grenades.

NOTE: Just prior to falling back to the bunker, EOD will check to be sure there is sufficient diesel fuel on the 12-inch wide area of propellant and that the rest of the propellant has been rewetted with water.

i. After insuring that the safety zone is clear, the motion picture camera is running, and the water system is turned on, EOD will initiate the thermite grenades.

j. EOD will determine proper re-entry time based on the results of the burn.

k. EOD, wearing respirators, will determine that the area and items are safe.

l. Prior to other observers approaching the item, Environmental Health will check for Hydrochloric Acid and asbestos contamination. If asbestos contamination is found, Environmental Health will wet down the area with an amended water solution until asbestos concentration is acceptable.

m. Other observers will be allowed at EOD's discretion to enter the area.

3.2.1 *Support—Equipment and Materials*

Camera Equipment: One fast speed (48 fps) 16mm camera
Fire Support (tanker truck)
Forklift (provided by Pan Am Ordnance)
M-14 Thermite Grenades (appropriate number) and required electrical initiator
Diesel Fuel
Passive Temperature Indicators
Vacuum Putty
Respirators with cartridges
Water Spray Equipment
Newage Portable Hardness Tester w/calibration blocks (provided by MSFC)
Amended water solution (provided by Environmental Health)
600-grit paper
Freon and wipes

3.3 *Hardware Identification*—The parts requiring propellant disposal will be defined in Figure 1.

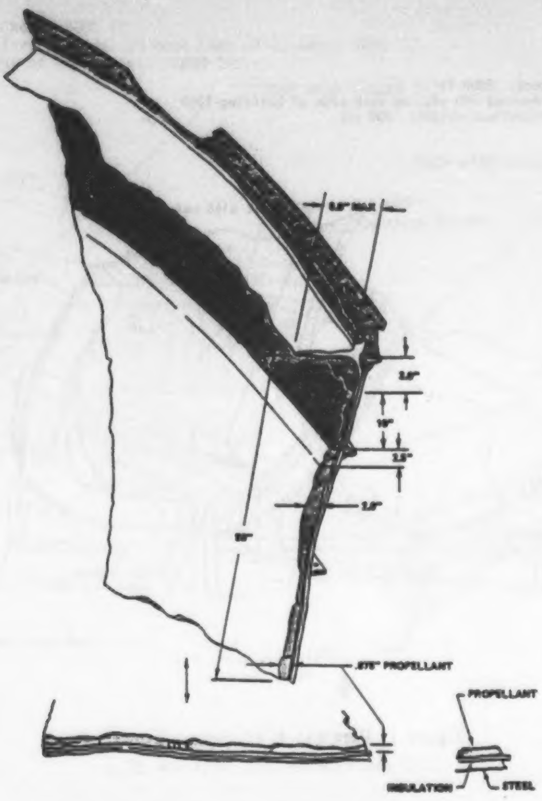
3.4 *Evidence Preservation*—Steps will be taken during the propellant disposal operation to preserve the hardware features that are critical to the failure investigation. Thermal protection such as vacuum putty, insulation blankets, and water spray and temperature indicators are required as shown in Figure 2.

3.5 *Hardware Disposition (Post Propellant Disposal)*—After the hardware has been declared to be safe by EOD/ESMC/NASA Safety, the part will be transported to Hangar "O" for storage.

3.6 *Propellant Residue Disposition*—In the event that incomplete combustion of the propellant occurs, the residue will be removed as directed by EOD personnel and disposition made in accordance with EOD Range procedures.

3.7 *Documentation*—A record of the disposal operation will be maintained by MSFC Engineer. The record will include the identification of the part (Figures 1 and 2), and the date and time of the operation, and any deviations from the planned operation. Film coverage of the actual propellant disposal shall be provided by use of one fast speed (48 fps) motion picture camera.

3.8 *Responsibility*—The ESMC EOD team shall be responsible for implementation of the propellant disposal operation. Technical support and equipment will be provided by NASA Operations.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19"
2.5"
2.0"
59"
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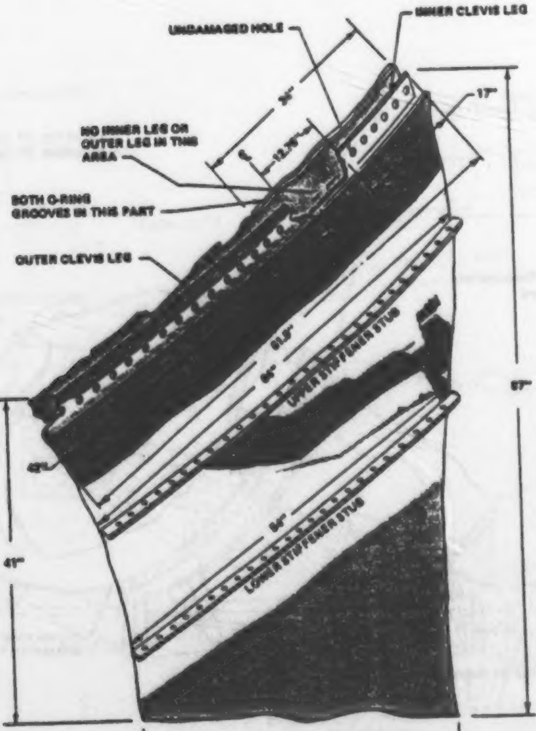
PROPELLANT
INSULATION
STEEL



UNDAMAGED HOLE
INNER CLEVIS LEG
36"
17"
NO INNER LEG OR
OUTER LEG IN THIS
AREA
12.75"
BOTH O-RING
GROOVES IN THIS PART
OUTER CLEVIS LEG
81.5"
84"
UPPER STIFFENER STUB
87"
42"
41"
84"
LOWER STIFFENER STUB
41"

INHIBITOR HT. = 8" MAX

Safety Clearance: 2000 ft.
Road blocks required 200 yds. on each side of building 1260
Approximate propellant weight: 600 lbs.

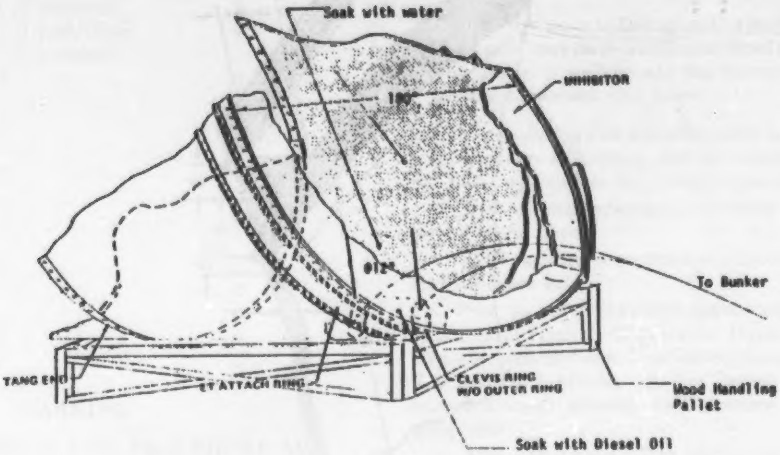

Soak with water
180°
INHIBITOR
012°
To Bunker
TANG END
ET ATTACH RING
CLEVIS RING
W/O OUTER RING
Wood Handling
Pallet
Soak with Diesel Oil

Figure 1, Part #11 L.H. Segment—ET attach

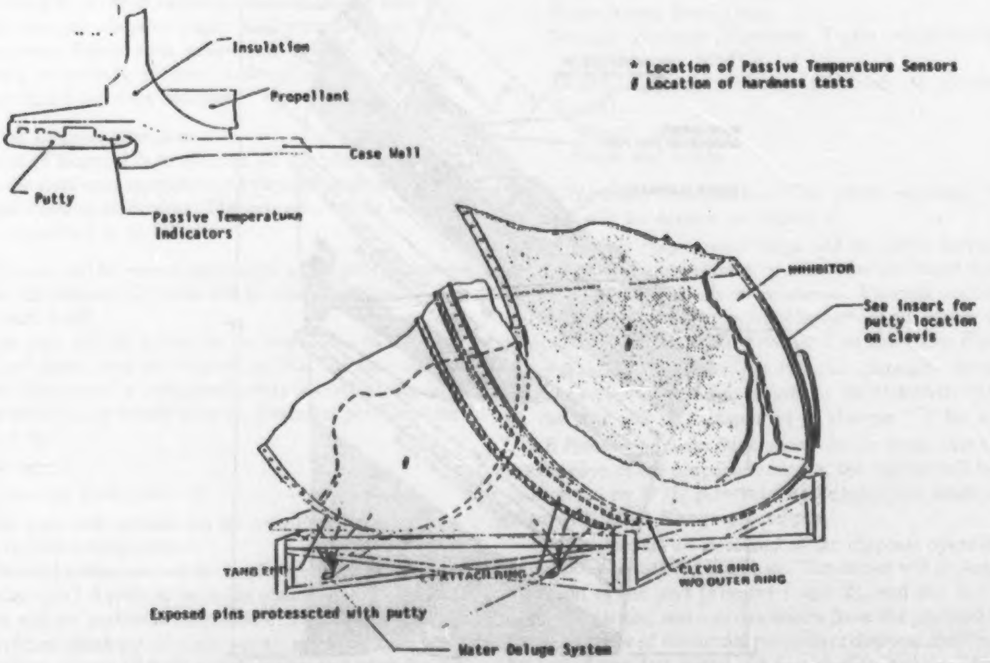

Insulation
Propellant
Case Wall
Putty
Passive Temperature
Indicators
* Location of Passive Temperature Sensors
# Location of hardness tests
INHIBITOR
See insert for
putty location
on clevis
TANG END
ET ATTACH RING
CLEVIS RING
W/O OUTER RING
Exposed pins protesscted with putty
Water Deluge System

Figure 2, Part #11 L.HL Segment—ET attach

SafetyClearance Area: 2000 ft.
Road blocks required 200 yds. on each side of building 1260
Approximate Weight of Propellant: 1200 lbs.

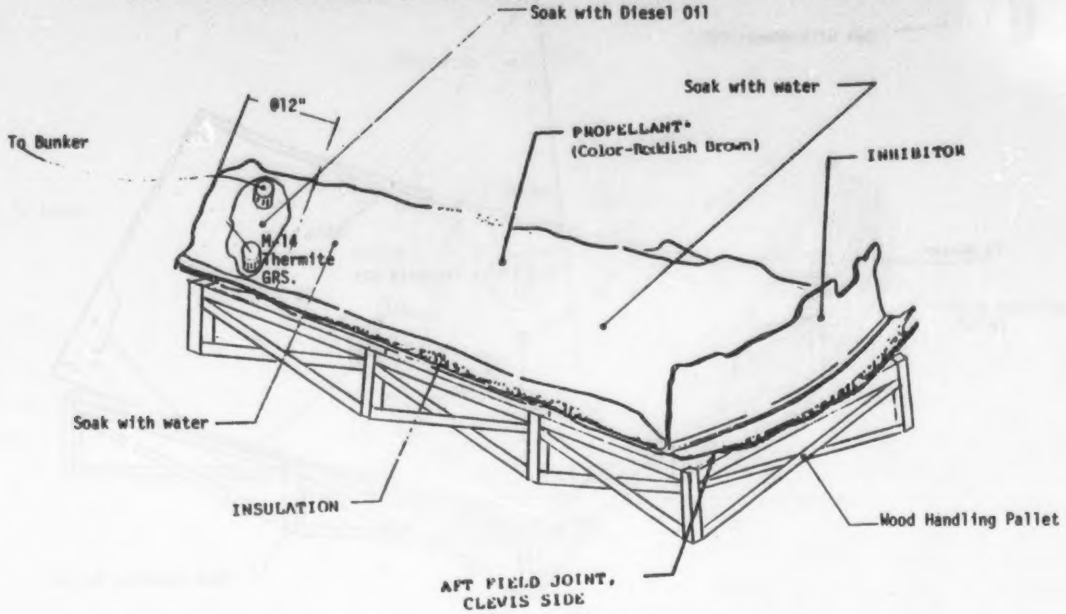

Soak with Diesel Oil
Soak with water
Ø12"
To Bunker
PROPELLANT*
(Color-Reddish Brown)
INHIBITOR
M-14
Thermite
GRS.
Soak with water
INSULATION
Wood Handling Pallet
AFT FIELD JOINT,
CLEVIS SIDE

Figure 1 Pt #26-2
L.H. Aft Ctr. Seg.—Fwd Case Cyl.

* Location of Passive Temperature Sensor
# Location of Hardness test

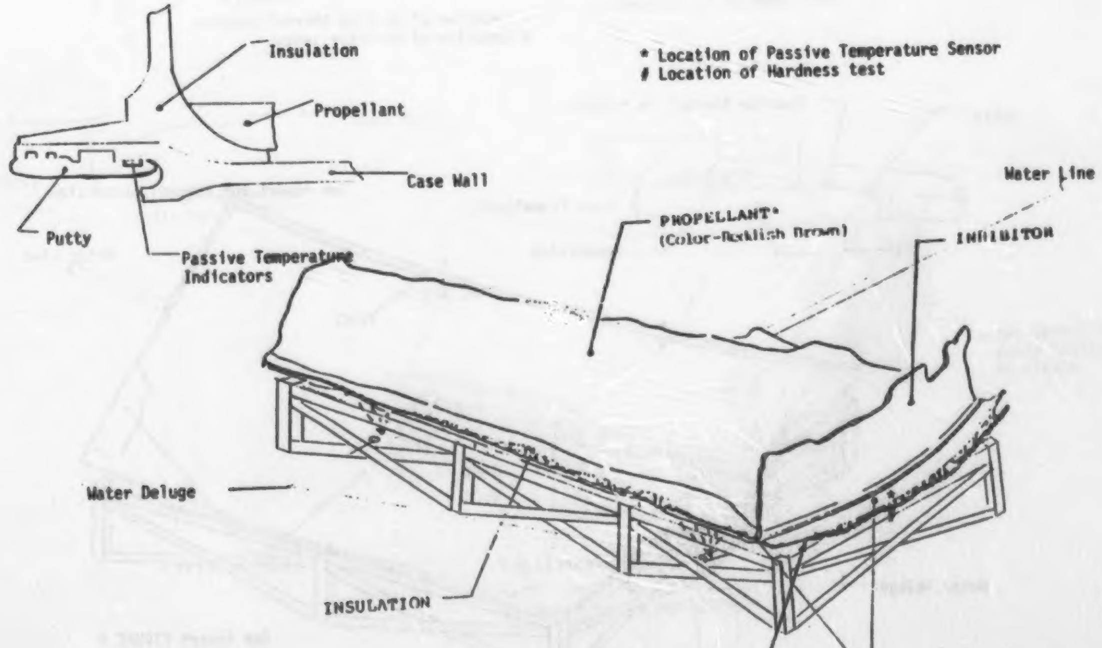

Insulation
Propellant
Case Wall
Putty
Passive Temperature
Indicators
Water Line
PROPELLANT*
(Color-Reddish Brown)
INHIBITOR
Water Deluge
INSULATION
AFT FIELD JOINT,
CLEVIS SIDE
See insert for putty
location for thermal
protection

Figure 2 Pt #26-2
L.H. Aft Ctrs. Seg-Fwd Case Cyl.

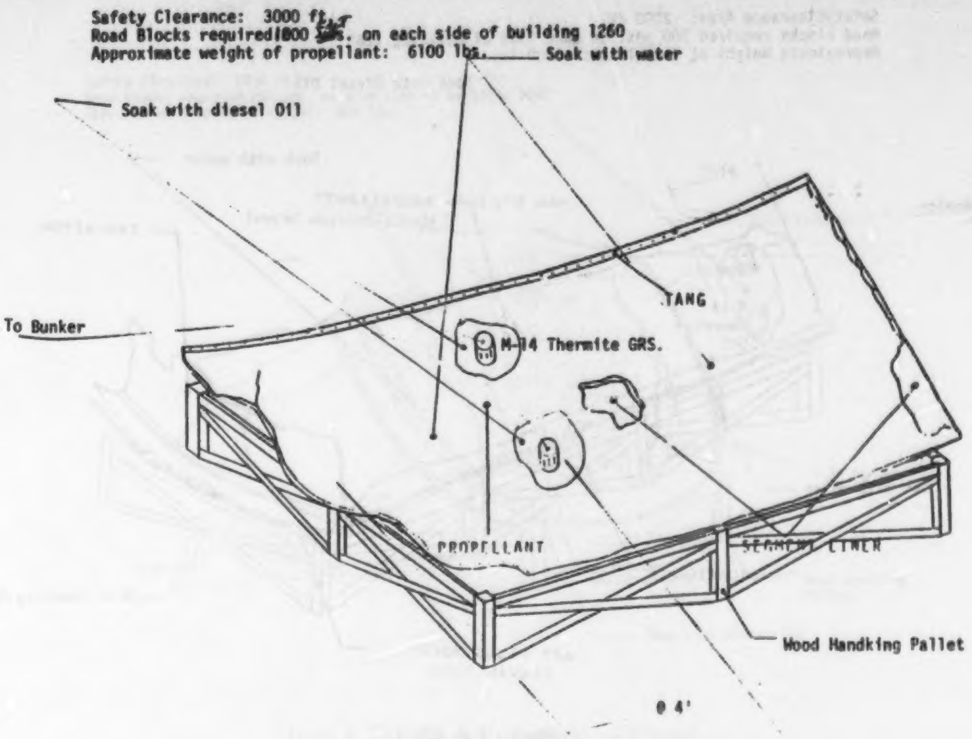

Safety Clearance: 3000 ft.
Road Blocks required 800 ft. on each side of building 1260
Approximate weight of propellant: 6100 lbs.
Soak with water
Soak with diesel Oil
To Bunker
TANG
M-14 Thermite GRS.
PROPELLANT
SEGMENT LINER
Wood Handking Pallet
@ 4'

Figure 1 Pt #195 Case Cylinder

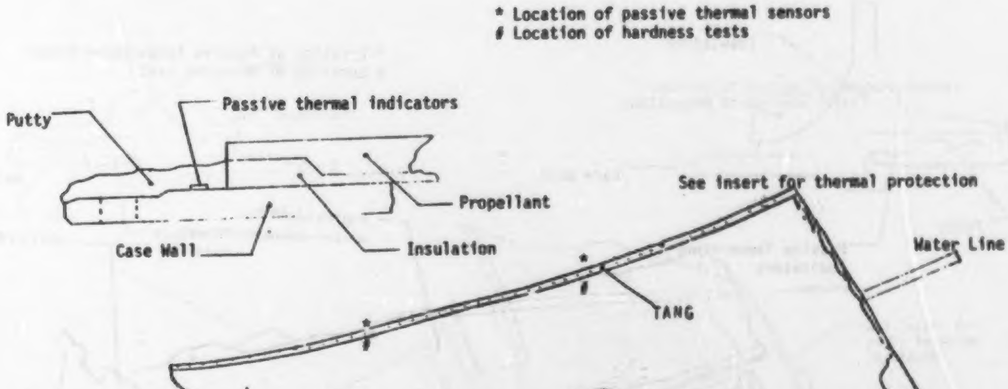

* Location of passive thermal sensors
# Location of hardness tests
Putty
Passive thermal indicators
Propellant
Case Wall
Insulation
See insert for thermal protection
Water Line
TANG
PROPELLANT
SEGMENT LINER
Water Deluge
See insert FIGURE 2 for clevis thermal protection

Figure 2 Pt #195 Case Cyl.

Safety Clearance: 1850 ft.
Road blocks required on each side of building 1260
● Approximate propellant weight: 500 lbs.

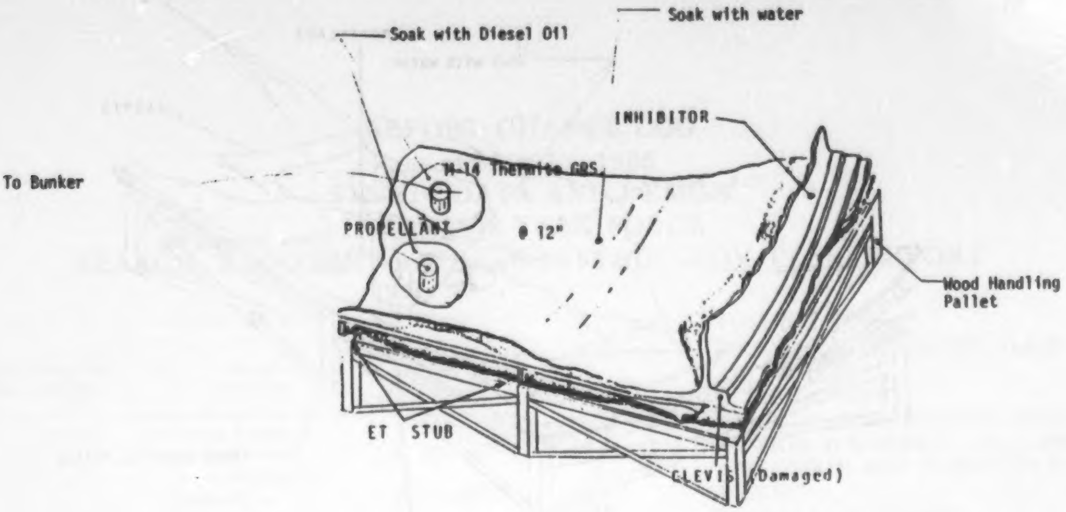

Soak with Diesel Oil
Soak with water
INHIBITOR
To Bunker
M-14 Thermite GRS
PROPELLANT
● 12"
Wood Handling Pallet
ET STUB
CLEVIS (Damaged)

Figure 1 Pt #292
R.H. Aft Seg.—ET Attach

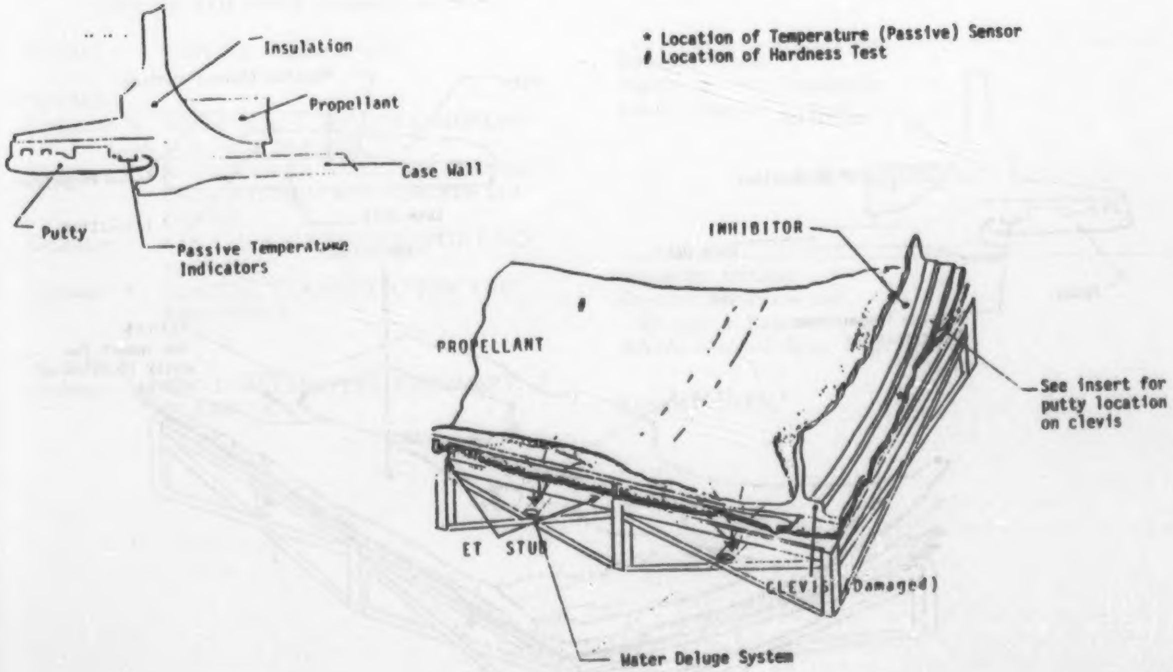

Insulation
Propellant
Case Wall
Putty
Passive Temperature Indicators
* Location of Temperature (Passive) Sensor
# Location of Hardness Test
INHIBITOR
#
PROPELLANT
See insert for putty location on clevis
ET STUB
CLEVIS (Damaged)
Water Deluge System

Figure 2 Pt #292
R.H. Aft Seg.—ET Attach

Safety Clearance: 2000 ft.
Road Blocks required 200 yds. on each side of building 1260
Approximate weight of propellant: 1000 lbs.

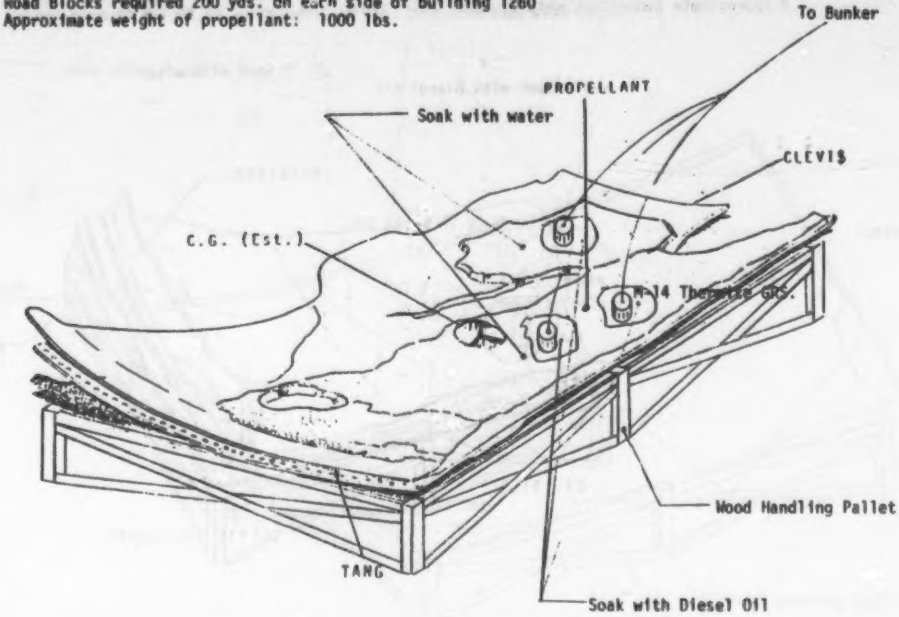

To Bunker
PROPELLANT
Soak with water
CLEVIS
C.G. (Est.)
M-14 Thermite GRS.
Wood Handling Pallet
TANG
Soak with Diesel Oil

Figure 1 Pt #301
R.H. Fwd. Seg.—Aft Cyl.

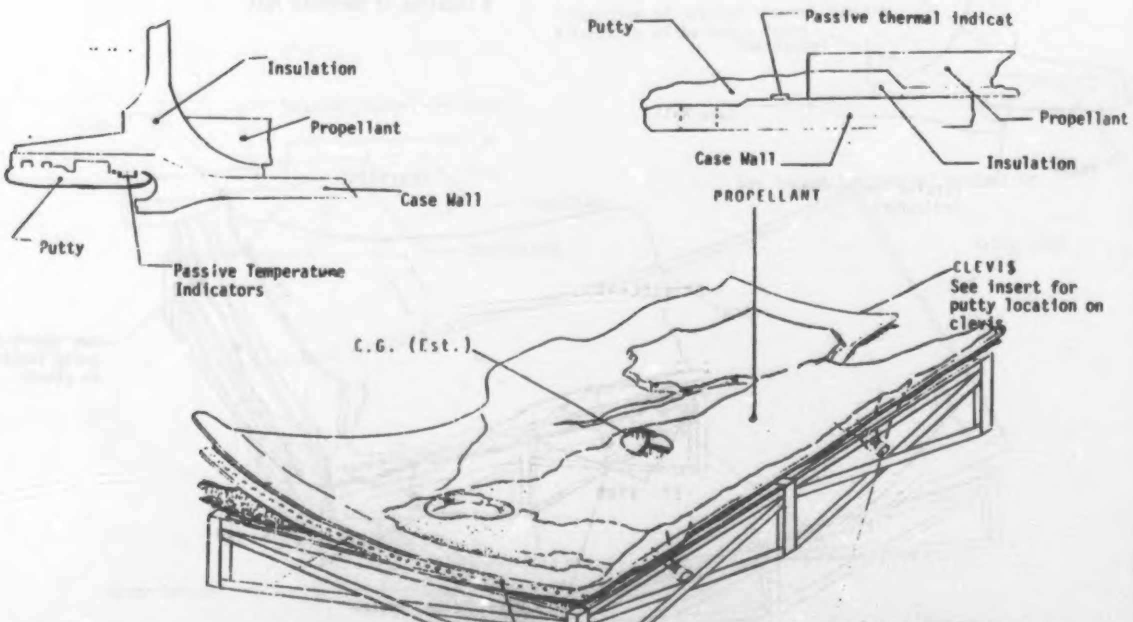

Insulation
Propellant
Case Wall
Putty
Passive Temperatune Indicators
Putty
Passive thermal indicat
Propellant
Case Wall
Insulation
PROPELLANT
CLEVIS See insert for putty location on clevis
C.G. (Est.)
ee insert for putty location on tang
TANG
Water Deluge System

Figure 2 Pt #301
R.H. Fwd. Seg.—Aft Cyl.

REPORT CHANGE LOG
as of May 12, 1986
STS 51-l DATA AND DESIGN ANALYSIS TASK FORCE
SEARCH, RECOVERY AND RECONSTRUCTION TEAM REPORT

VOLUME 4

CHANGE NOTICE NO.	CHANGE NOTICE DATE	PAGES AFFECTED	ITEMS AFFECTED
1	5/12/86	1) Create Volume 4	
		Enclosure 6 (From Volume 2)	No Change
		Enclosure 7 (From Volume 2)	No Change
		Enclosure 8 (From Volume 2)	Complete Update
		Enclosure 9 (Added Enclosure)	New Text

Colonel Edward A. O'Connor, Jr. Date

LIST OF VOLUMES (separately bound)

VOLUME 1		REPORT SUMMARIES
VOLUME 2	Enclosure 1	MISSION 51-L SHUTTLE MISHAP—SURFACE SEARCH
	Enclosure 2	RADAR DATA ANALYSIS AND IMPACT ESTIMATION FOR STS 51-L DEBRIS
	Enclosure 3	STS 51-L RIGHT SRB REPORT NO. 82-SR-86-07
	Enclosure 4	SEARCH, CLASSIFICATION AND RECOVERY
VOLUME 3	Enclosure 5	SRB INCREMENTAL RECOVERY PLANNING
VOLUME 4		THIS VOLUME
	Enclosure 6	RECOVERED ET DEBRIS HARDWARE ASSESSMENT
	Enclosure 7	OCEANOGRAPHY
	Enclosure 8	SPACE TRANSPORTATION SYSTEM, MISSION 51-L STRUCTURAL RECONSTRUCTION AND EVALUATION REPORT (Standard Accident Report)
	Enclosure 9	CONTACT #131 AND #712 RECOVERED RH SRB AFT FIELD JOINT EVALUATION

RECOVERED EXTERNAL TANK DEBRIS HARDWARE ASSESSMENT
April 10, 1986

PREPARED BY:

John W. Beaton
Martin Marietta Corporation
Launch Support Services

APPROVED BY:

Alexander McCool
Director, Structures and
Propulsion Laboratory
NASA, Marshall Space Flight Center

ENCLOSURE 6

RECOVERED ET DEBRIS HARDWARE ASSESSMENT

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RECOVERED ET DEBRIS HARDWARE ASSESSMENT

A. *INTRODUCTION*

To date, approximately 200 pieces of Light Weight Tank (LWT-19(51L)) have been recovered. Approximately 100 of these pieces are foam/Thermal Protection System (TPS) items. The remaining hardware consists of portions of the Liquid Hydrogen (LH_2), Liquid Oxygen (LO_2), and intertank skin panels. Other recovered debris includes cable trays, fairings, ordnance, and the External Tank (ET)/Orbiter LO_2 disconnect.

The majority of the debris, which was recovered within the first 10 days after the accident, was found floating on the Atlantic Ocean.

All recovered debris is photographed when received at KSC and assigned and tagged with a log number for traceability. The numbers shown on the "maps" and matrix included with this report are the assigned log numbers.

After receipt of the debris, exposed metallic surfaces were rinsed with fresh water and all fracture surfaces were brushed with nylon brushes and sprayed with WD-40 to prevent corrosion.

Any work performed on hardware was documented and photographed before, during, and after execution. Any photographs that are needed can be obtained through the Kennedy Space Center (KSC) Task Force and must be requested by debris log number.

B. *RECOVERED HARDWARE REVIEW*

1. *Interface Hardware*

The only piece of interface hardware recovered was the ET/Orbiter LO_2 disconnect. Both the ET and the Orbiter halves were recovered still mated by the pyro separation bolts.

No ET/Solid Rocket Booster (SRB) interface/attachment hardware has been recovered.

2. *Press Lines, Cable Trays, and Other External Hardware*

The three sections of LH_2 cable tray and forward section (3 ft.) of the LO_2 containing the linear-shaped charge/confined detonating fuse (LSC/CDF) were recovered floating. Both the LO_2 and LH_2 LSC/CDF were fractured but not detonated.

Other external hardware recovered includes:

Nose Cone Fairing
$-y$ Vert Strut Cable Tray
GO_2 Press Line Mount at X_T 752
Portion of LO_2 Umbilical Cable Tray
$+y$ Vert Strut Transition Cable Tray
$+y$ ET/SRB Bolt Catcher
GO_2 Press Line Guide Rail
GH_2 Press Line Fairing from Cross Beam

3. *LO_2 Feedline*

Three sections of LO_2 Feedline were recovered, one section approximately 3 ft. long with the mating flanges from Station (STA) X_T 1372 and two sections of aluminum line approximately 10 feet long, that cannot be precisely located on the longitudinal axis.

4. *LO_2 Tank*

Six pieces of LO_2 tank were recovered. One item's location has been determined in the original configuration. None of the five remaining pieces can be precisely located, but four are believed to be parts of the forward LO_2 ogive section and one is believed to be from the aft dome. Six pieces of the LO_2 slosh baffles were recovered but they also cannot be precisely located in the original configuration.

5. *LH_2 Tank Skin*

Six pieces of LH_2 tank skin were recovered; four were floating on the ocean and two were salvaged from the ocean bottom. Item 1543 was originally thought to be from the $+y$ (right-hand) side near the ET/SRB strut and had a hole that appeared to be a burn through when viewed in the underwater films. After recovery, positive identification showed it to be located near $-y$ (left-hand) from STA X_T 1871-2000, and the hole, which was approximately 2 inches by 4 inches, occurred when part of the 1871 "T" ring tore loose, therefore, it was not a burn through.

Item #0064 is the piece of structure where a weld imperfection was detected at the $-z$ longitudinal weld at the junction of the upper 2058 ring weld. X-rays were done of the suspect area on the debris at KSC and compared with the build x-rays at Michoud. Analysis of these x-rays showed no propagation of the imperfection and fracture analysis determined this area was not a start of ET break-up nor a contributing factor of the accident. A more detailed explanation is contained in the fractographic analysis section.

All recovered LH_2 debris shows mild surface scorching of the TPS foam but there is no evidence of severe heat that melted or burned through any tank structure. At this time, no parts of the ET from the areas of the right- or left-hand ET/SRB aft attach points have been located or recovered.

There have been five pieces of LH_2 tank internal intermediate ring frames recovered that can be identified as to location on the longitudinal axis but not the circumferential axis.

6. *Intertank Skin Panels*

Fifty-three pieces of intertank were recovered as floating debris. Forty-one pieces have been precisely located on the original configuration. Of the remaining 12 pieces, ten are portions of individual stringers that have been separated from the skin and range in length from 2 inches to 2 feet. The remaining two skin panels are less than 36 square inches and too small to precisely locate.

The external TPS surface of the recovered panels shows evidence of heating and varied degrees of charring that range from no evidence of heat to several pieces that are heavily charred. There is no discernible pattern to the burning. Pieces that are heavily charred match to pieces that show no evidence of any heat. This indicates that the parts were in high heat environments after break-up. Visual observation of all interior intertank surfaces show no indication of any heat or fire damage, which indicates that no explosion or any fire originated from inside the intertank.

7. *ET/SRB Cross Beam*

Five pieces of the ET/SRB cross beam webbing have been recovered to date. None of the major structural members of the beam have been found. The exact location of the recovered webbing cannot be determined. Pieces range from 36 square inches to 200 square inches.

8. *TPS Foam/SLA Debris*

Approximately 100 pieces of foam insulation were recovered as floating debris. Positive location has been made on some of these, others have been identified as coming from the LO_2, LH_2, intertank, or PAL ramps, but exact location cannot be determined. This debris will not provide any evidence useful to the investigation.

C. *RECOVERED HARDWARE ASSESSMENTS*

1. *Fractographic Analysis*

All the major fracture faces were visually examined to determine fracture propagation direction, fracture origins, fracture mechanism (slow fracture vs. fast fracture), material imperfections, and any other topographical feature. In some areas, a 10x eyepiece was used to better examine the fracture features. Plastic replicas were made of the fracture face on Item 0064 at the HAG-7 ($-z$ at upper X_T 2058 ring weld junction) weld, and the replicas were then examined with a scanning electron microscope (SEM).

2. *LO_2 Tank Hardware*

The one significant piece of LO_2 hardware, Item 0065, that has been recovered to date, failed along the OAF weld (X_T 852), ODG welds (285°, 345°), and along the second and third dome stiffening ring. All the fracture faces indicate a rapid fracture mode. A review of weld x-rays indicated no weld imperfections in this area.

3. *Intertank Hardware*

Because of the large number of intertank pieces and secondary cracks, the visual examination concentrated on the major features. In general, the majority of fractures were in a shear mode (rapid fracture). Fractures at the aft end of the stringers near the LH_2 tank (X_T 1123) are of a compression type indicating forward motion of the LH_2 tank. The two more interesting fractures were associated with the main intertank frame located at STA 985. On intertank Panel No. 311, the 985 frame section that is protruding past the piece itself is bent inboard. Considering the bulk of the frame, a considerable force would be required to bend the frame. Other than water impact, the only explanation would involve (slow) contact with the forward end of the SRB. This hypothesis appears more likely than water impact, based on the undistorted condition of the skin/stringers on panel 311. The Mating Panel, No. 0657, shows no external damage.

On the intertank Panel No. 0267, the piece of 985 frame still attached to the thrust panel indicated a slower (plain strain) type fracture. The lengthwise fracture of this same intertank panel also appeared to slow down near the 985 frame region. This may be expected because of the load carrying capability of the intertank in this area.

4. *LH_2 Tank Hardware*

The fracture faces of the recovered LH_2 tank hardware yielded the most interesting findings:

a. As mentioned elsewhere in this report, a 0.400-inch crack-like imperfection was discovered to be unreported. The location of the imperfection was along the HAG-7 weld intersection with the H1 weld (Upper 2058 Ring Frame). Considerable attention was given to the recovered hardware from this area.

b. The recovered $-z$ barrel No. 1 hardware very likely contained the 0.400-inch imperfection. Following is the step-by-step methodology used to determine if the 0.400-inch imperfection was recovered, and if so, was there any flaw growth, and did the imperfection contribute to the overall fracture scenario.

   (1) An x-ray overlay of the HAG-7 weld and its distinguishing features was made and it included the 0.400-inch indication. This overlay was taken to KSC and compared with the recovered weld's features and the path of the fracture. The result indicated that the STS 51-L fracture went through the 0.400-inch indication.

   NOTE: It could not be determined from the original x-ray whether the imperfection was near the ISL (upper) or the OSL (lower).

   (2) Next, the area of the 0.400-inch imperfection was visually examined at magnifications up to 10x. No pre-existing defect was observed.

   (3) A replica was then made of the fracture face areas indicated by the x-ray film overlay. The replica method consists of using an acetate film softened with acetone and pressing the film against the fracture face. The film dries in 5 to 10 minutes and is stripped away. The replica is placed in a vacuum chamber where a 200-angstrom layer of 60% gold/40% palladium is applied. The coated replica is then viewed with the scanning electron microscope (SEM).

   (4) An extensive examination of the replica of the HAG-7 weld did not reveal a pre-existing flaw or indicate any slow or cyclic flaw growth (Striations).

   (5) After the SEM work, the HAG-7 weld was radiographically inspected to locate the 0.400-inch imperfection with respect to the recovered fracture face. These new x-ray films reconfirmed that the 0.400-inch indication was on the recovered fracture face.

   (6) Additional visual examination of the HAG-7 weld revealed a single gas pore approximately 2 inches aft of the 0.400-inch imperfection. Review of the original x-ray film indicated four very small (up to 0.050-inch diameter) pores in this area. The KSC x-ray films revealed that the fracture pore was most likely to be the 0.050-inch pore. Examination of the adjacent fracture topography suggests that the region of the pores was a secondary origin of the HAG-7 fracture itself. With a calculated critical flaw size of at least 5 inches, the porosity can only be considered a secondary effect.

   (7) Except for the HAG-7 weld, no other longitudinal fractures occurred through a weld.

   (8) Except for short transitional fractures, all circumferential fractures were along weld heat-affected zones or fusion lines.

   (9) All circumferential weld fractures occurred on the extrusion side of the weld joint.

   (10) Whereas the longitudinal parent metal fractures were shear type, the circumferential weld fractures characteristically had a "woody" type fracture topography. (This is likely a result of the typical layered microstructure of an extrusion. However, this item should be considered for further study.)

5. *LO_2 Feedline*

With only an 0.800-inch thickness and physical wear to the fracture face, an exact analysis was difficult. However, the fracture features indicated a rapid fracture. An interesting observation of the feedline TPS was the number of imbedded Orbiter particles, including pieces of mylar, gold, and pieces of graphite/epoxy composite.

6. *LO_2 Feedline Fairing*

The fairing apparently was torn from the intertank. Examination of the interior of the fairing suggested a strong upward force/impact from the feedline itself. All fracture features indicated a rapid fracture.

7. *Aft GH2 Pressline Fairing*

This fairing also failed by overload in a rapid manner.

8. *Miscellaneous Cable Tray Parts*

All fracture features indicated a rapid fracture.

D. *CONCLUSION*

Analysis of the recovered ET hardware provided no evidence to indicate that an ET imperfection contributed to the STS 51-L accident.

E. *ATTACHMENTS*

A matrix (Table 1) has been included showing whether debris floated, degrees of charring, or other pertinent information.

Four "maps" (Figures 1 through 4) have been included as part of this report to show the exact location on the ET of all the debris that was recovered and positively identified.

RECOVERED DEBRIS MATRIX

Debris Item #	Floating	Sunken	General Location	Degree of Heat Charring None	Light	Med.	Heavy	Pos ID	Remarks
0002	X		I/T	X				X	
0005	X		I/T	X				X	
0007	X		I/T			X		X	
0008	X		LO2 Fairing	X				X	
0059	X		+Y Bipod MA25 SLA	X				X	
0060	X		I/T		X				Small Stringer Fragment
0061	X		I/T Foam						Multiple TPS Fragments
0062	X		LO2 TPS						Multiple TPS Fragments
0064	X		LH2		X			X	Weld Imperfection
0065	X		LO2	X				X	
0066	X		I/T		X			X	
0067	X		I/T					X	
0069	X		BX 250						Multiple TPS Fragments
0070	X		I/T						Stringer Fragment
0071	X		I/T				X	X	
0072	X		I/T			X		X	
0073	X		I/T	X				X	
0074	X		I/T	X				X	
0075	X		I/T				X	X	
0076	X		I/T		X			X	
0077	X		I/T			X		X	
0078	X		I/T	X				X	
0079	X		I/T		X			X	
0080	X		LO2 TPS						Multiple TPS Fragments

TABLE 1
1 OF 5

RECOVERED DEBRIS MATRIX

Debris Item #	Floating	Sunken	General Location	Degree of Heat Charring None	Light	Med.	Heavy	Pos ID	Remarks
0081	X		I/T			X		X	
0082	X		LO2 F/L	X				X	
0083	X		LH2		X			X	
0084	X		LO2 F/L			X			Multiple Imbedded Possible ORB Fragments
0085	X		I/T		X			X	
0086	X		GH2 PL Fairing			X		X	
0087	X		I/T		X			X	
0092	X		LH2 C/T	X				X	
0120	X		I/T				X	X	
0196	X		I/T		X				Stringer Fragment
0197	X		P/L Mount	X				X	
0230	X		C/T Assy	X				X	LH2 C/T Fragment ID Possible
0231	X		GO2 P/L BKT	X				X	
0232	X		LO2 TPS		X			X	Multiple Fragments
0233	X		AT C/T	X				X	
0234			LO2 TPS		X				Multiple Fragments
0263	X		I/T	X				X	
0264	X		I/T		X			X	
0265	X		I/T				X	X	
0266	X		LH2			X		X	
0267	X		I/T	X				X	
0268	X		-Y Vert Strut C/T	X				X	
0269	X		+Y Vert Strut C/T	X				X	

TABLE 1
2 OF 5

RECOVERED DEBRIS MATRIX

Debris Item #	Floating	Sunken	General Location	Degree of Heat Charring				Pos ID	Remarks
				None	Light	Med.	Heavy		
0270	X		LO2 F/L				X		Some Imbedded ORB Fragments
0271	X		I/T		X			X	
0288	X		LH2		X			X	
0290	X		I/T	X				X	Skin Fragment
0307	X		I/T		X			X	
0308	X		I/T			X		X	
0309	X		I/T		X			X	
0310	X		I/T				X	X	
0311	X		I/T		X			X	
0312	X		I/T		X			X	
0313	X		I/T		X			X	
0314	X		I/T	X				X	
0368	X		TPS						Multiple Fragments
0401	X		I/T		X				Stringer Fragment
0443	X		I/T		X				Stringer Fragment
0444	X		I/T		X			X	Stringer Fragment
0445	X		I/T		X			X	
0446	X		I/T		X				Stringer Fragment
0447	X		I/T	X				X	
0448	X		I/T	X				X	
0502	X		TPS	X					Multiple Fragments
0511	X		I/T	X				X	
0512	X		I/T		X			X	
0541	X		I/T		X				Stringer Fragment
0542	X		TPS		X				Multiple Fragments
0543	X		I/T	X				X	
0544	X		I/T	X				X	

TABLE 1
3 OF 5

RECOVERED DEBRIS MATRIX

Debris Item #	Floating	Sunken	General Location	Degree of Heat Charring				Pos ID	Remarks
				None	Light	Med.	Heavy		
0571	X		TPS						Multiple Fragments
0572	X		TPS						Multiple Fragments
0579	X		TPS						Multiple Fragments
0592	X		TPS						Multiple Fragments
0602	X		TPS						Multiple Fragments
0605	X		TPS						Multiple Fragments
0652	X		I/T		X				Stringer Fragment
0653	X		I/T	X					Skin Fragment
0656	X		TPS						Multiple Fragments
0657	X		I/T				X	X	
0661	X		Nose Cone Fairing	X				X	
0679	X		+Y ET/SRB Bolt Catcher	X				X	
0697	X		TPS						Multiple Fragments
0703	X		TPS						Multiple Fragments
0846	X	X	LO2 Skin			X			Possible Ogive Fragment
0847		X	LH2 Ring	X					Intermediate "Z" Ring
0848		X	LO2 Skin			X			Possible Ogive Fragment
0849		X	LH2 Ring	X					Intermediate "Z" Ring
0850		X	LH2 Ring	X					Intermediate "Z" Ring
0851		X	LH2 Ring	X					Intermediate "Z" Ring
0868		X	LO2 Skin			X			Possible Ogive Fragment
0869	X		I/T		X				Stringer Fragment
0870		X	LO2 Skin			X			Possible Ogive Fragment

TABLE 1
4 OF 5

RECOVERED DEBRIS MATRIX

Debris Item #	Floating	Sunken	General Location	Degree of Heat Charring				Pos ID	Remarks
				None	Light	Med.	Heavy		
0871		X	LO2 Slosh Baffles	X					Multiple Fragments
0872		X	LH2 Ring	X					Intermediate "Z" Ring
0893		X	ET/SRB Beam Web	X					
0935		X	LO2 Skin	X				X	Part of Aft Dome
0994		X	LO2 Disconnect			X		X	Both ET and ORB Halves
1503		X	ET/SRB Beam Web	X					
1543		X	LH2	X				X	
1566		X	LH2 Ring	X				X	Intermediate "Z" Ring
1567		X	ET/SRB Beam Web	X X				X	
1568		X	ET/SRB Beam Web	X					
1569		X	ET/SRB Beam Web	X					
1601	X		TPS						Multiple Fragments
1602	X		TPS						Multiple Fragments
1626-1	X		LH2 C/T		X			X	Attached Together
1626-2	X		LH2 C/T		X			X	With Entire
1626-3	X		LH2 C/T		X			X	Length of LSC
1626-4	X		LO2 C/T	X				X	Contained Fwd Section of LSC

TABLE 1
5 OF 5

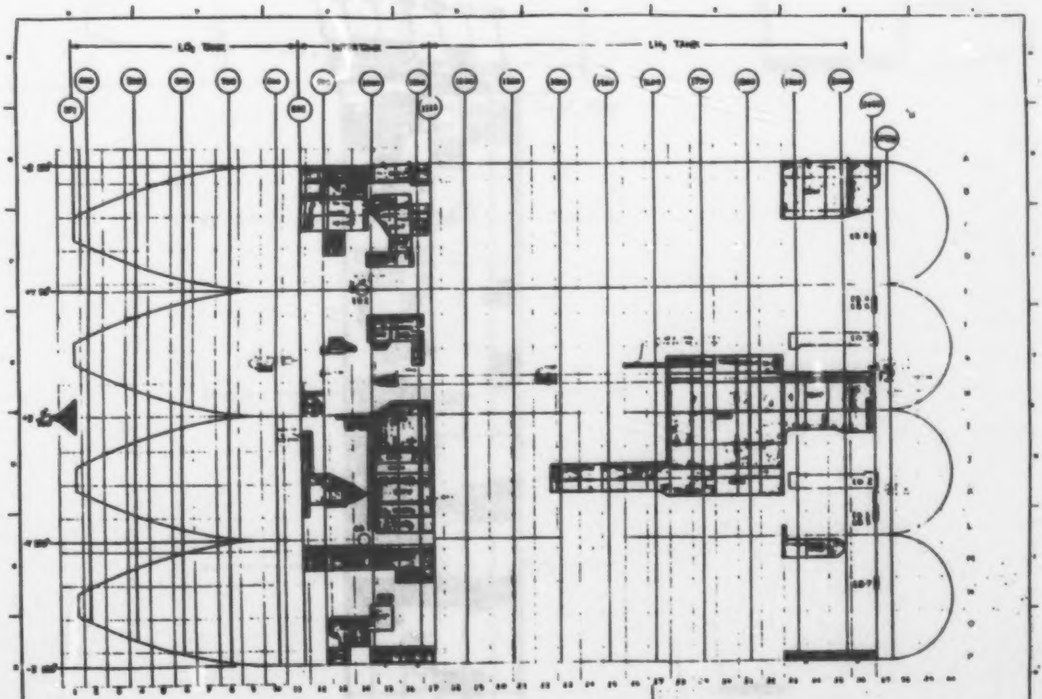

Figure 1. External Tank Map

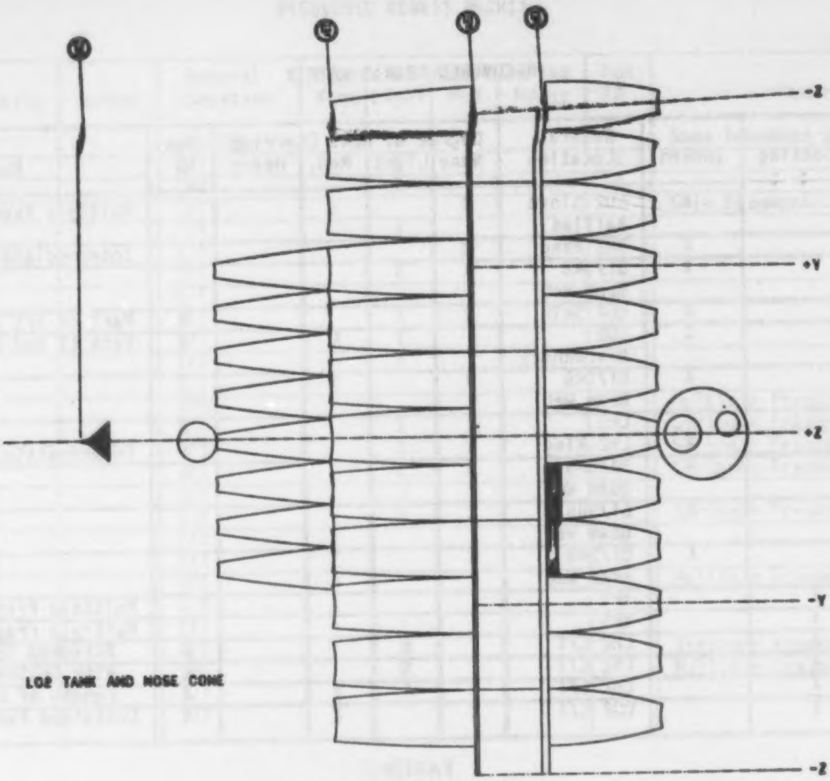
-Z
+Y
+Z
-Y
-Z
LO2 TANK AND NOSE CONE

Figure 2. LO$_2$ Tank Map

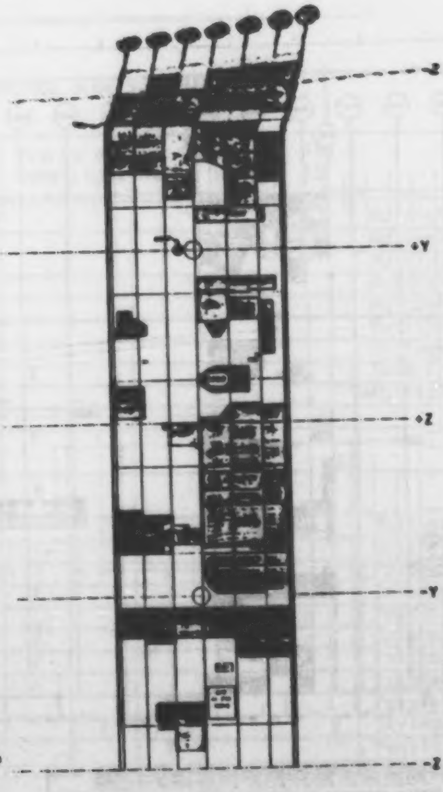
-Z
+Y
+Z
-Y
-Z
INTERTANK

Figure 3. Intertank Map

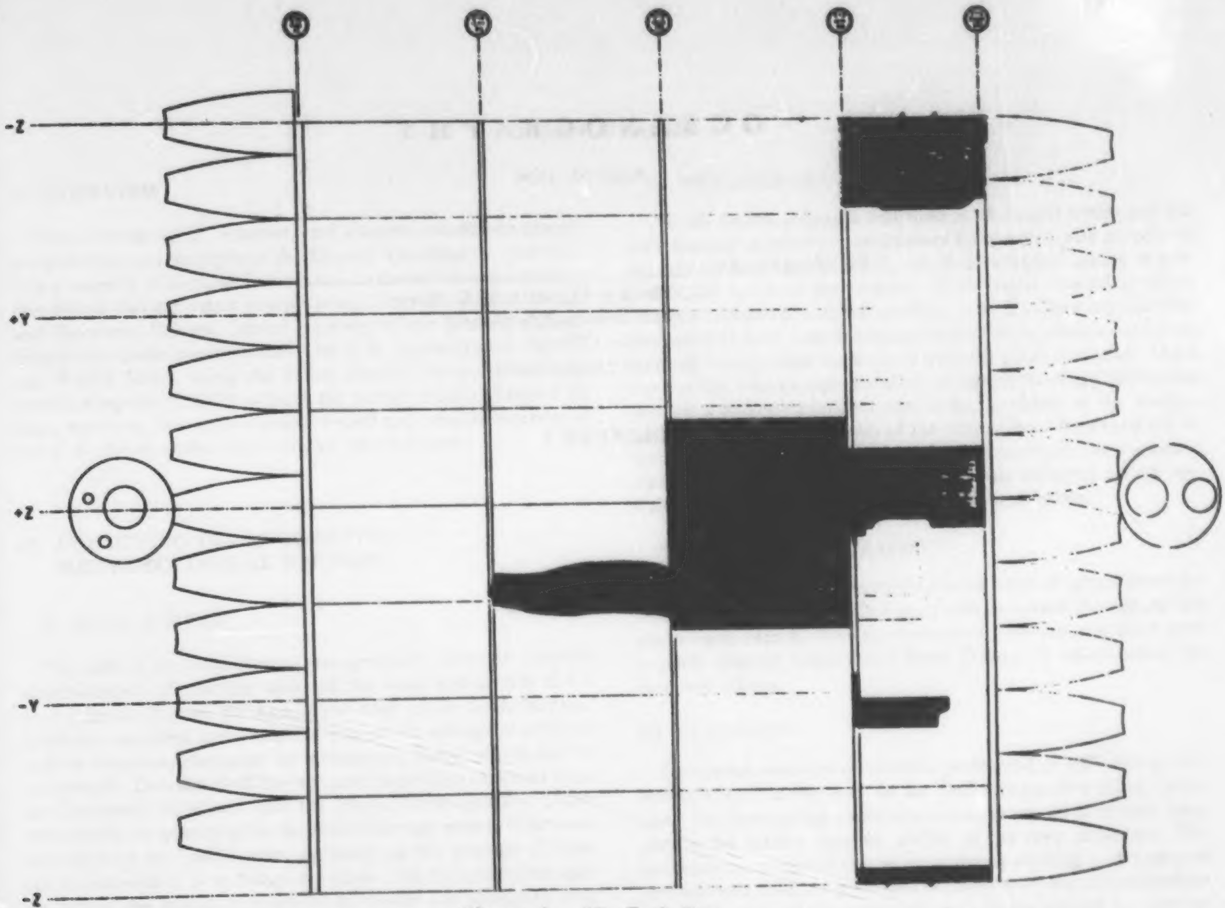

Figure 4. LH$_2$ Tank Map

OCEANOGRAPHY

April 10, 1986

PREPARED BY: ______________________
CDR Don Mautner, U.S. Navy
Ocean Science Advisor
Astronaut Office
Johnson Space Center

ENCLOSURE 7

OCEANOGRAPHY

I. OVERVIEW

The oceanographic, weather, and sea state conditions played a significant role throughout the Shuttle, Challenger, recovery. The proximity of the Gulf Stream axis to the surface and subsurface debris was the major complicating factor during the Search and Recovery Process. Initial recovery of the floating surface debris was made predominantly by U.S. Coast Guard, Navy, and NASA Ships, using the Coast Guard Computer Assisted Search Program (CASP) to track the surface debris. Beyond 10 days, however, the surface search ended and implementation of the U.S. Navy underwater salvage efforts began.

II. IMPACTING OCEANOGRAPHIC/ METEOROLOGICAL FACTORS

A. *GULF STREAM*

The axis of the Gulf Stream was generally stable in position approximately 50 nautical miles off the coast with speeds of 3.5 to 4.5 knots (Figure 1). The inner edge of the Gulf Stream, however, extended to the western edge of the salvage search box and on occasion, disrupted or terminated diving efforts due to its strength. Detailed Gulf Stream current profiles obtained from the University of Miami and the Naval Oceanographic Office were useful for planning by the Navy Salvage teams. Westward meanders in the Gulf Stream occurred on the average of twice per month with a 3- to 5-day duration. The meanders brought the axis of the stream in closer to the beach and disrupted dive operations in the shallow portions of the search area for several days.

B. *WEATHER/SEA STATE*

Weekly frontal passages resulting in increased winds and sea state hampered recovery operations for the first two months of operations. By April 1, 1986, the climatological spring migration to the north of the primary storm tracks created excellent diving conditions and significantly improved underwater visibility (from 5 to 15 feet). Late fall storms in the North Atlantic, however, generated long period swell waves from the north-northeast. These swell waves, when coupled with the northerly flowing Gulf Stream created a severe turbulence and silting problem in the shallow portions (less than 150 feet) of the search box. Resulting silt in the shallow areas accumulated to 18" to 24" in depth covering many smaller pieces of the Shuttle debris. Only minimal silting was observed in the deeper portions of the search box.

C. *BOTTOM TOPOGRAPHY*

Detailed Bottom Topography charts were obtained from the Woods Hole Institute of Oceanography and used throughout the underwater search. Fine to coarse sand bottoms prevailed with a gently-sloping Continental Shelf (Figure 2) which aided the recovery efforts.

III. *SUMMARY*

Successful recovery operations performed in the vicinity of a strong ocean current such as the Gulf Stream, is a tricky operation. The hampering winds and sea state served to further complicate the station keeping ability of the dive platforms. The documented success of the recovery teams working in this adverse environment reflects a great deal of credit upon the professionalism and dedication of the personnel and divers aboard the salvage ships.

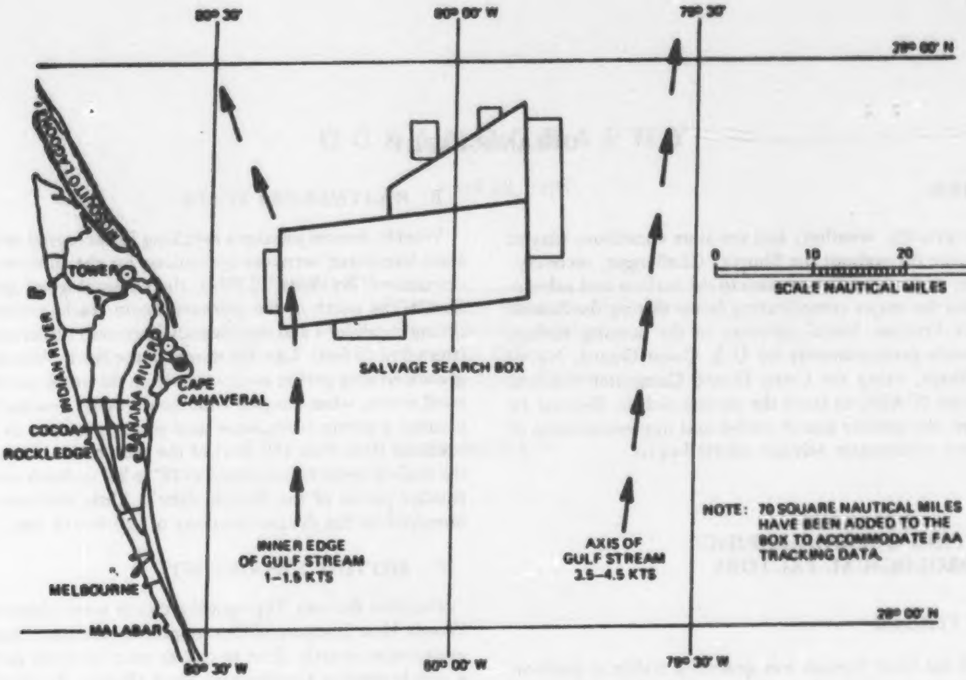
80° 30'
80° 00' W
79° 30'
29° 00' N
MOSQUITO LAGOON
TOWER
INDIAN RIVER
BANANA RIVER
CAPE CANAVERAL
COCOA
ROCKLEDGE
MELBOURNE
MALABAR
SALVAGE SEARCH BOX
0
10
20
30
SCALE NAUTICAL MILES
NOTE: 70 SQUARE NAUTICAL MILES HAVE BEEN ADDED TO THE BOX TO ACCOMMODATE FAA TRACKING DATA.
INNER EDGE OF GULF STREAM 1–1.5 KTS
AXIS OF GULF STREAM 3.5–4.5 KTS
28° 00' N
80° 30' W
80° 00' W
79° 30' W

FIGURE 1 Oceanographic Gulf Stream Impact

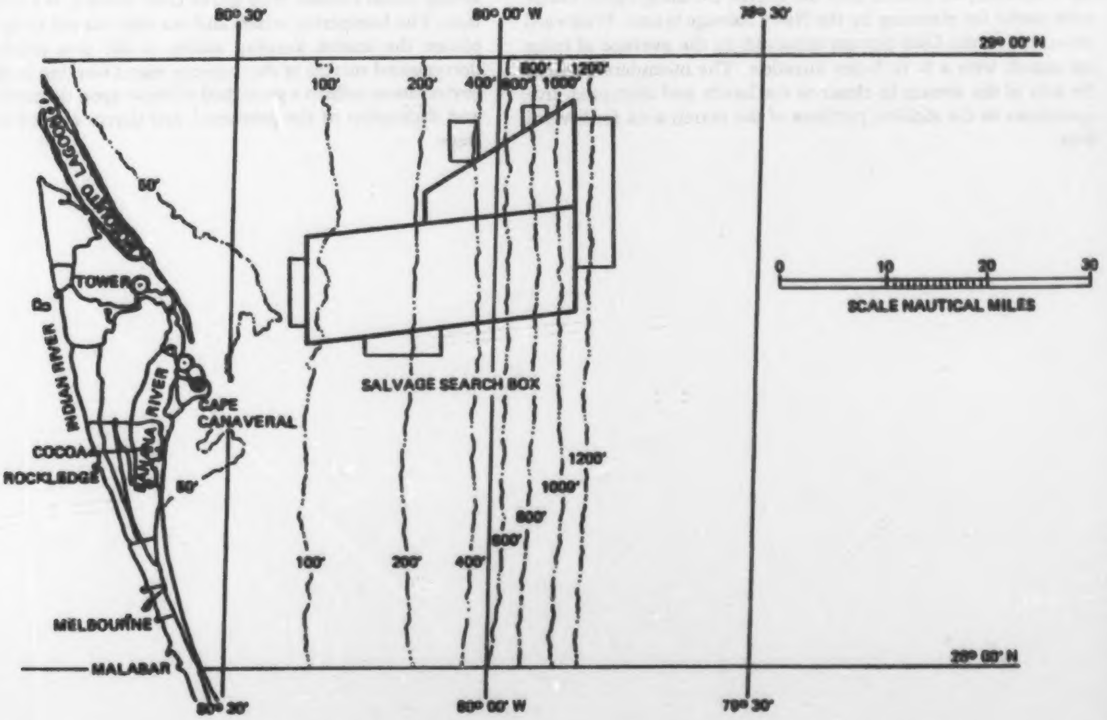
80° 30'
80° 00' W
79° 30'
29° 00' N
100'
200'
400'
600'
800'
1000'
1200'
MOSQUITO LAGOON
50'
TOWER
INDIAN RIVER
BANANA RIVER
CAPE CANAVERAL
COCOA
ROCKLEDGE
50'
SALVAGE SEARCH BOX
0
10
20
30
SCALE NAUTICAL MILES
1200'
1000'
800'
600'
100'
200'
400'
MELBOURNE
MALABAR
28° 00' N
80° 30'
80° 00' W
79° 30'

FIGURE 2 Bottom Depths (Feet)

SPACE TRANSPORTATION SYSTEM
MISSION 51-L
STRUCTURAL RECONSTRUCTION AND EVALUATION REPORT

May 8, 1986

APPROVED BY: __________________________

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APPROVED BY: __________________________

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Remarks:

This report utilizes the manufacturer's coordinate system. This system was selected because the reconstruction process required use of the manufacturer's drawings. Reference Figures 1 and 2 for the axes and coordinates.

The Photo and TV Support Team utilized the flight dynamics coordinate system which is illustrated in Volume 1 of their report.

SPACE TRANSPORTATION SYSTEM, MISSION 51-L
STRUCTURAL RECONSTRUCTION AND EVALUATION REPORT

A. ACCIDENT

LOCATION: Atlantic Ocean near the Kennedy Space Center
DATE: January 28, 1986, at 11:39 EST
VEHICLE: Space Transportation System, Mission 51-L
OPERATOR: National Aeronautics and Space Administration

B. STRUCTURAL EVALUATION GROUP

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C. SUMMARY

About 11:38 EST on January 28, 1986, Space Transportation System (STS) Mission 51-L departed Launch Pad 39B at the John F. Kennedy Space Center, Florida, with seven astronauts aboard. As observed and recorded on television and other film, about 72 seconds after liftoff, STS 51-L was nearly engulfed in a huge ball of fire, and it began to disintegrate. Both solid rocket boosters (SRB's) separated from the external tank (ET) and continued powered flight on erratic courses until linear-shaped charges (LSC's) on the SRB's were detonated by the Range Safety Officer (RSO); the charges destroyed both SRB's. Numerous large pieces of the Orbiter, "Challenger," and the ET were observed on the film to descend out of the fireball into the Atlantic Ocean east-northeast of the Kennedy Space Center (KSC). Also, the pieces of the SRB's fell into the ocean east-northeast of KSC.

During the several days following the accident, investigation teams were formed at the KSC to investigate the accident. A structural reconstruction and evaluation group was formed as a part of the Search, Recovery, and Reconstruction Team headed by Colonel Edward O'Connor, USAF, to evaluate all of the structure of STS 51-L that was recovered from the Atlantic Ocean. After cleaning with fresh water, the recovered parts of the structure were impounded in several buildings at the KSC where pieces were identified, cataloged, and arranged in two-dimensional mock-ups for detailed examination. A visual examination on the deformation and fractures of the pieces recovered was performed in order to assess their probable mode of failure and to establish a probable breakup sequence. Also, samples were taken of selected pieces which had either burn damage or deposits of a foreign matter. Laboratory analyses were then performed on these samples to determine the probable source of the heat or to identify the deposits of foreign material. The laboratory tests performed were X-ray Diffraction, Scanning Electron Microscopy/Energy Dispersive Spectroscopy, Infrared Spectroscopy, and Microprobe/Wavelength Dispersive Spectroscopy.

About 30 percent of the structure of the STS 51-L was recovered during the three months following the accident. Other pieces were identified by underwater television on the floor of the Atlantic Ocean but were not recovered because the pieces were deemed not significant to the determination of the probable cause of the accident. The structure deemed significant to the determination of probable cause consisted of certain portions of the right SRB from which fire was observed on film to have erupted about 58 seconds after lift-off. Also deemed significant were structural portions of the ET in the vicinity of the fire, including the lower fittings which attached the right SRB to the ET, and the crew module. The search for the structural component of STS 51-L consumed hundreds of thousands of hours of effort; however, much of the structure was never found. The suspect RH SRB aft field joint pieces were recovered and debris still being recovered should have no effect on the team findings.

The significant pieces of Orbiter structure recovered included all three Space Shuttle Main Engines (SSME's), the forward fuselage including the crew module, the right inboard and outboard elevons, a large portion of the right wing, a lower portion of the vertical stabilizer, three rudder speed brake panels, and portions of mid fuselage side walls from both the left and right sides. This represented about 30 percent of the Orbiter and did not provide sufficient evidence to conclusively establish the complete failure sequence of the entire Orbiter spacecraft. However, there was sufficient evidence to establish some of the probable structural failure modes that resulted in destruction of the Orbiter.

All fractures and material failures examined on the Orbiter, with the exception of the SSME's, were the result of overload forces, and they exhibited no evidence of internal burn damage or exposure to explosive forces. This indicated that the destruction of the Orbiter occurred predominantly from aerodynamic, acceleration, and inertial forces that exceeded design limits. There was evidence that during the breakup sequence, the right SRB struck the outboard end of the Orbiter's right wing and right outboard elevon. Additionally, the right side of the Orbiter probably was sprayed by hot propellant gases exhausting from the hole in the inboard circumference of the right-hand (RH) SRB. Evaluation of the Orbiter main engines indicated extensive thermal damage to the engines as a consequence of oxygen-rich operation that results from a shut-off of the hydrogen fuel supply. The supply of hydrogen fuel to the main engines would have been abruptly shut off when the liquid hydrogen (LH$_2$) tank in the ET disintegrated.

Evaluation of the limited amount of Orbiter structure recovered revealed no evidence to indicate that a failure or malfunction of structural components within the Orbiter, including the payload package, contributed to the cause of this accident.

The crew module wreckage was found submerged in about 90 feet of ocean water and was concentrated in an area of about 20 feet by 80 feet. Portions of forward fuselage outer shell structure were found among the pieces of crew module recovered. There was no evidence of an internal explosion, heat, or fire damage on the crew module pieces or on the forward fuselage pieces. The crew module was disintegrated with the heaviest fragmentation and crush damage on the left side. The fractures examined were typical of overload breaks and appeared to be the result of high forces generated by impact with the surface of the water. The sections of lower forward fuselage outer shell found floating on the ocean surface, which were recovered shortly after the accident, also contained crush damage of an impact on the left side. The consistency of damage to the left side of the outer fuselage shell and crew module indicates that these structures remained attached to each other until impact with the water. Supportive evidence which strongly indicates that the crew module remained an essentially intact structure until impact with the water was the concentration of its pieces in only one small area on the ocean bottom.

The majority of ET hardware recovered was found as floating debris and consisted mainly of pieces from the intertank and LH$_2$ tank. The foam insulation on the recovered pieces of ET skin structure had various amounts of surface scorching; however there was no discernible pattern to the scorch damage except that some of the scorching occurred following disintegration of the ET. None of the metal structure beneath the insulation had melted or was burned through. Portions of LSC's from both the LH$_2$ and LO$_2$ tanks were recovered; they had not detonated. Examination of the fracture patterns on pieces from the LH$_2$ tank indicated that it probably broke apart due to external overload forces rather than from an internal overpressure. Only a small portion of LO$_2$ tank was recovered and examined. The appearance of the fractures on the LO$_2$ tank pieces was indicative of a tank failure caused by excessive internal pressure. Close examination of the fracture surfaces on the ET revealed several minor weld imperfections in the LH$_2$ tank structure. Detailed evaluation of these imperfections indicated that they were not a factor to the STS Mission 51-L accident. All fractures examined on the recovered pieces of ET were the result of overload forces.

As of May 1, 1986, 42 pieces of SRB had been recovered including 2 pieces of the right SRB (sidescan sonar Contact Nos. 131 and 712) that identified the approximate dimensions of the hole burned through the side of the SRB near the lower field joint. The evaluation of these two pieces is contained in Volume 4, Enclosure 9 of this report. Since these two pieces of the right SRB contained the physical evidence pertinent to the failure of the SRB, further search and recovery efforts for pieces of SRB were discontinued as of the above date.

All casing fractures of the other 40 pieces of SRB were the results of overload forces or of case penetration by LSC explosives. The right SRB frustum showed clear evidence of forceful contact with ET intertank structure at the 245- to 255-degree position on the base of the frustum. This evidence indicates that failure of the liquid oxygen (LO$_2$) tank in the ET may have been precipitated by the frustum's forceful contact with and disruption of intertank structure.

D. INTRODUCTION

For the purpose of reconstructing and evaluating the recovered structure of STS Mission 51-L, the system (see Figure 1 for typical STS) was separated into three major subsystems: (1) The Orbiter, Challenger, including its main engines (SSME's), the Main Propulsion System (MPS), and the payload bay contents, (2) the External Tank (ET), and (3) the two Solid Rocket Boosters (SRB's). Brief descriptions of the above subsystems follow:

1. *ORBITER* (see Figures 2 and 3 for typical Orbiter)

The Orbiter structure is made primarily of conventional aluminum construction protected by reusable surface insulation. The structure is divided into six major sections, which are the forward fuselage, crew module, mid fuselage, wings, aft fuselage, and main engines. The forward fuselage structure is divided into upper and lower sections that fit clam-like around the pressurized crew module. The crew module, which is supported within the forward fuselage at four primary attachment points, is welded to create a pressure-tight vessel. The module has a side hatch for normal passage and a hatch from the airlock into the mid fuselage payload bay area. The mid fuselage connects to the rear of the forward fuselage at the 582 frame. The mid fuselage is a 60-foot

Shuttle Coordinate Systems and Dimensions

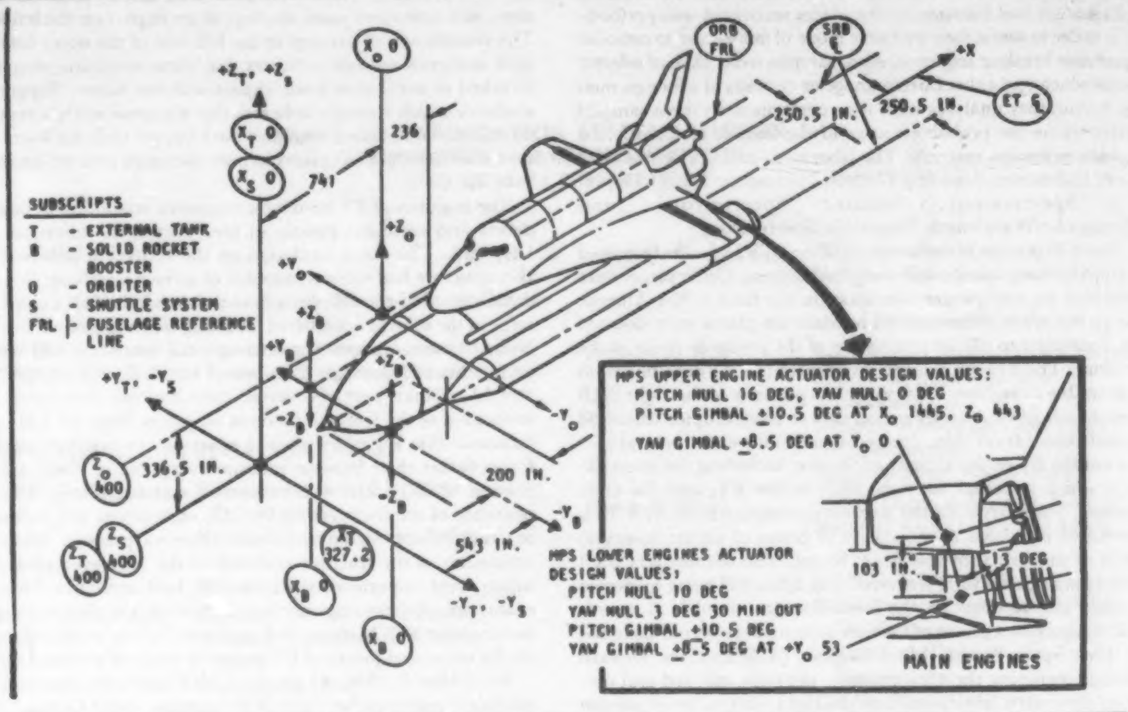
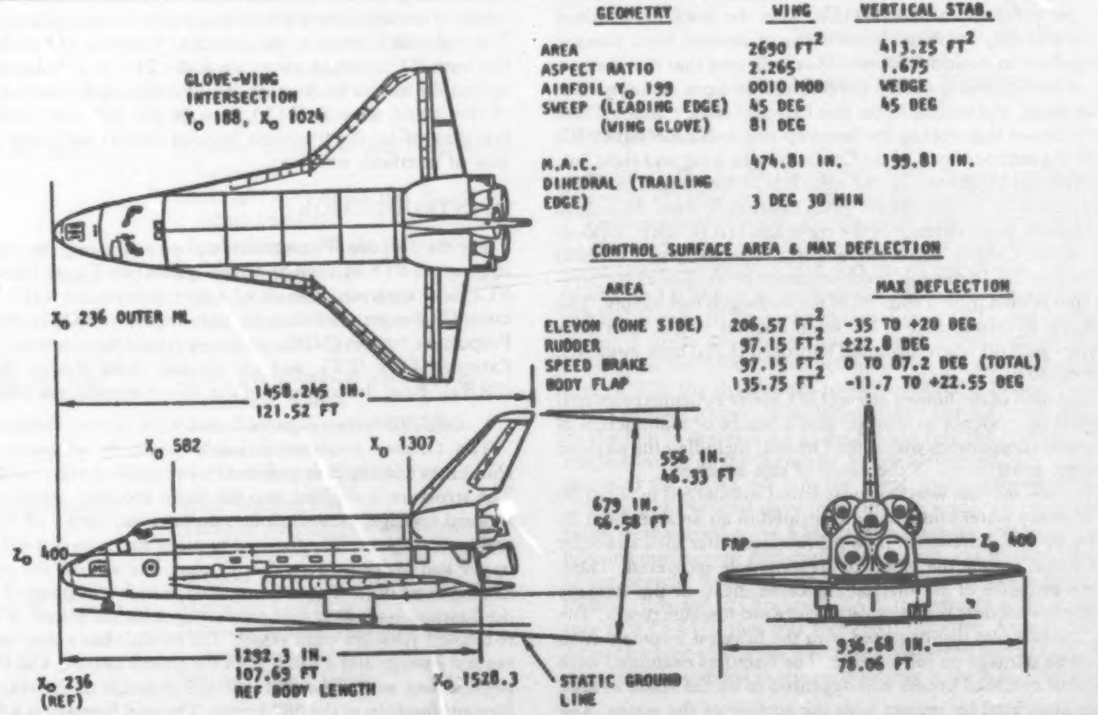

X_O 0
$+Z_T$, $+Z_S$
X_T 0
X_S 0
236
741
$+Z_O$
$+Y_O$
$+Z_B$
$+Y_B$
$+Z_B$
$-Z_B$
$+Y_T$, $-Y_S$
$-Y_O$
Z_O 400
336.5 IN.
200 IN.
$-Z_B$
$-Y_B$
X_T 327.2
Z_S 400
Z_T 400
543 IN.
X_B 0
$-Y_T$, $-Y_S$
X_B 0
ORB FRL
SRB ℄
+X
250.5 IN.
250.5 IN.
ET ℄
SUBSCRIPTS
T - EXTERNAL TANK
B - SOLID ROCKET BOOSTER
O - ORBITER
S - SHUTTLE SYSTEM
FRL ⊢ FUSELAGE REFERENCE LINE
MPS UPPER ENGINE ACTUATOR DESIGN VALUES:
PITCH NULL 16 DEG, YAW NULL 0 DEG
PITCH GIMBAL ±10.5 DEG AT X_O 1445, Z_O 443
YAW GIMBAL ±8.5 DEG AT Y_O 0
MPS LOWER ENGINES ACTUATOR DESIGN VALUES:
PITCH NULL 10 DEG
YAW NULL 3 DEG 30 MIN OUT
PITCH GIMBAL ±10.5 DEG
YAW GIMBAL ±8.5 DEG AT $+Y_O$ 53
103 IN.
13 DEG
MAIN ENGINES

FIGURE 1

Orbiter Vehicle Dimensions


GLOVE-WING INTERSECTION
Y_O 188, X_O 1024
X_O 236 OUTER ML
1458.245 IN.
121.52 FT
X_O 582
X_O 1307
556 IN.
46.33 FT
679 IN.
56.58 FT
FRP
Z_O 400
Z_O 400
1292.3 IN.
107.69 FT
REF BODY LENGTH
X_O 236 (REF)
X_O 1528.3
STATIC GROUND LINE
936.68 IN.
78.06 FT

GEOMETRY	WING	VERTICAL STAB.
AREA	2690 FT^2	413.25 FT^2
ASPECT RATIO	2.265	1.675
AIRFOIL Y_O 199	0010 MOD	WEDGE
SWEEP (LEADING EDGE)	45 DEG	45 DEG
(WING GLOVE)	81 DEG	
M.A.C.	474.81 IN.	199.81 IN.
DIHEDRAL (TRAILING EDGE)	3 DEG 30 MIN	

CONTROL SURFACE AREA & MAX DEFLECTION

	AREA	MAX DEFLECTION
ELEVON (ONE SIDE)	206.57 FT^2	-35 TO +20 DEG
RUDDER	97.15 FT^2	±22.8 DEG
SPEED BRAKE	97.15 FT^2	0 TO 87.2 DEG (TOTAL)
BODY FLAP	135.75 FT^2	-11.7 TO +22.55 DEG

FIGURE 2

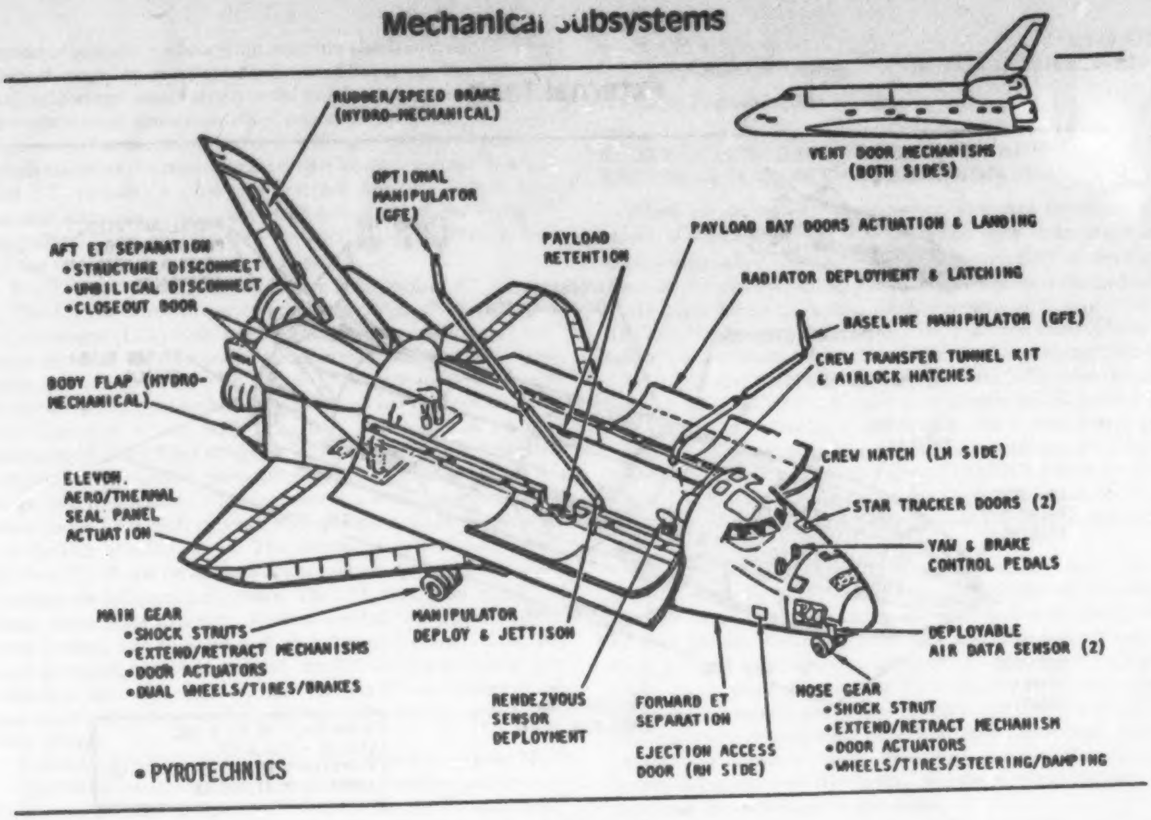
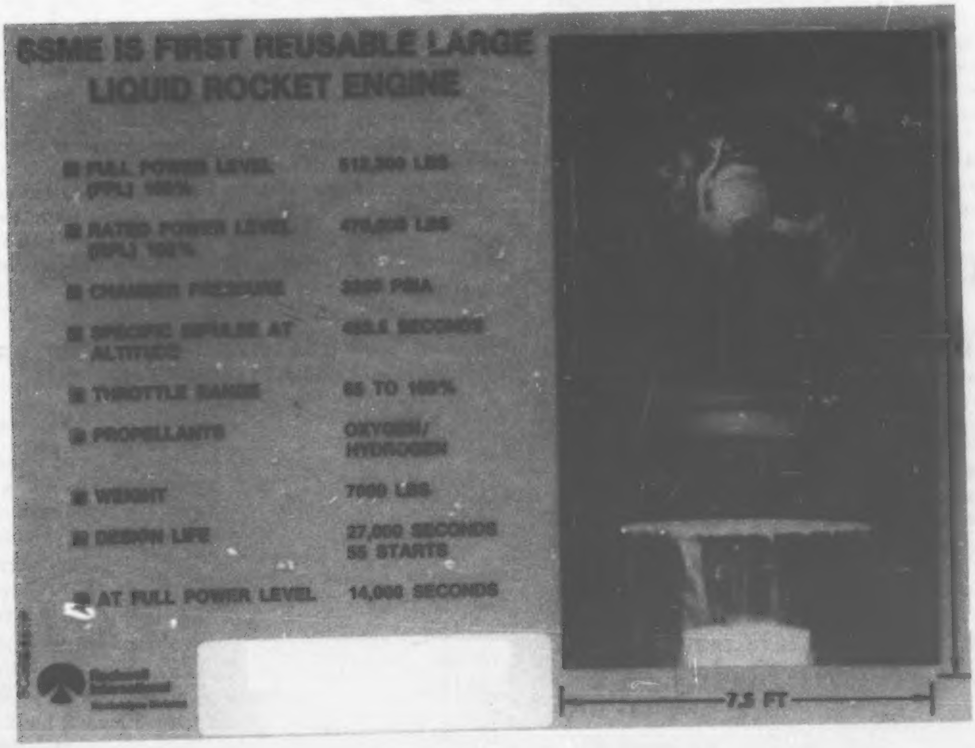

Mechanical Subsystems
RUDDER/SPEED BRAKE (HYDRO-MECHANICAL)
VENT DOOR MECHANISMS (BOTH SIDES)
OPTIONAL MANIPULATOR (GFE)
AFT ET SEPARATION
•STRUCTURE DISCONNECT
•UMBILICAL DISCONNECT
•CLOSEOUT DOOR
PAYLOAD RETENTION
PAYLOAD BAY DOORS ACTUATION & LANDING
RADIATOR DEPLOYMENT & LATCHING
BASELINE MANIPULATOR (GFE)
CREW TRANSFER TUNNEL KIT & AIRLOCK HATCHES
BODY FLAP (HYDRO-MECHANICAL)
CREW HATCH (LH SIDE)
ELEVON, AERO/THERMAL SEAL PANEL ACTUATION
STAR TRACKER DOORS (2)
YAW & BRAKE CONTROL PEDALS
MAIN GEAR
•SHOCK STRUTS
•EXTEND/RETRACT MECHANISMS
•DOOR ACTUATORS
•DUAL WHEELS/TIRES/BRAKES
MANIPULATOR DEPLOY & JETTISON
DEPLOYABLE AIR DATA SENSOR (2)
RENDEZVOUS SENSOR DEPLOYMENT
FORWARD ET SEPARATION
EJECTION ACCESS DOOR (RH SIDE)
NOSE GEAR
•SHOCK STRUT
•EXTEND/RETRACT MECHANISM
•DOOR ACTUATORS
•WHEELS/TIRES/STEERING/DAMPING
• PYROTECHNICS

FIGURE 3



SSME IS FIRST REUSABLE LARGE LIQUID ROCKET ENGINE

- FULL POWER LEVEL (FPL) 109% — 512,300 LBS
- RATED POWER LEVEL (RPL) 100% — 470,000 LBS
- CHAMBER PRESSURE — 3260 PSIA
- SPECIFIC IMPULSE AT ALTITUDE — 455.5 SECONDS
- THROTTLE RANGE — 65 TO 109%
- PROPELLANTS — OXYGEN/ HYDROGEN
- WEIGHT — 7000 LBS
- DESIGN LIFE — 27,000 SECONDS 55 STARTS
- AT FULL POWER LEVEL — 14,000 SECONDS

Rockwell International
Rocketdyne Division
7.5 FT

FIGURE 4

External Tank

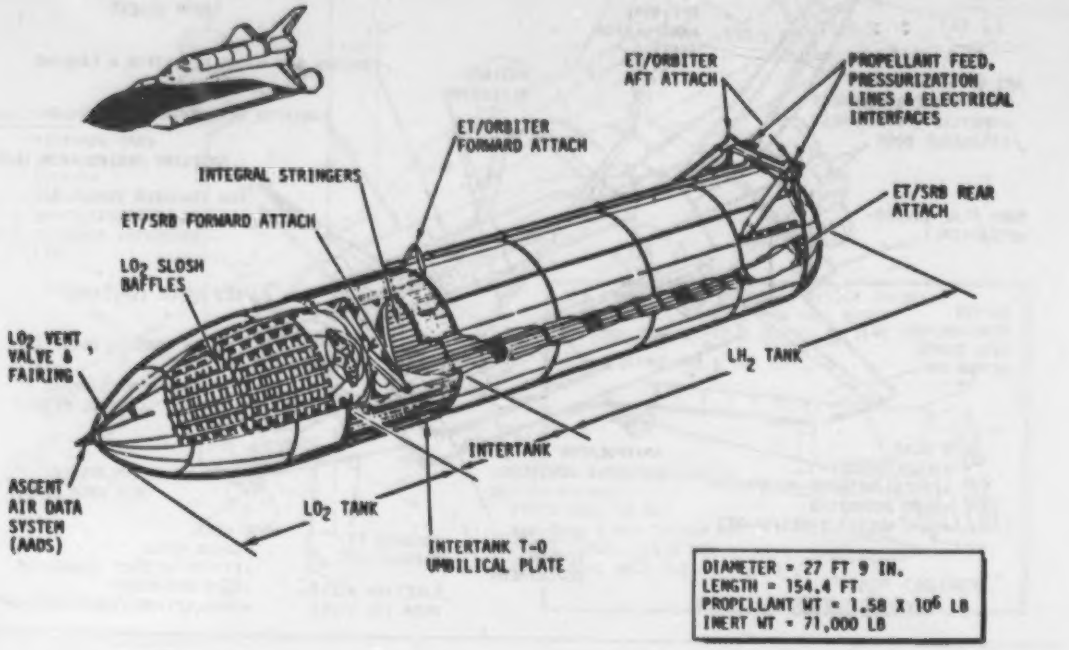

ET/ORBITER AFT ATTACH
PROPELLANT FEED, PRESSURIZATION LINES & ELECTRICAL INTERFACES
ET/ORBITER FORWARD ATTACH
INTEGRAL STRINGERS
ET/SRB REAR ATTACH
ET/SRB FORWARD ATTACH
LO2 SLOSH BAFFLES
LO2 VENT VALVE & FAIRING
LH2 TANK
INTERTANK
ASCENT AIR DATA SYSTEM (AADS)
LO2 TANK
INTERTANK T-0 UMBILICAL PLATE
DIAMETER = 27 FT 9 IN.
LENGTH = 154.4 FT
PROPELLANT WT = 1.58 X 10^6 LB
INERT WT = 71,000 LB

FIGURE 5

section of primary load-carrying structure which contains the wing carry-through structure and the payload bay area. The left wing and right wings, which attach to the mid fuselage, are constructed of conventional aluminum alloy, and each wing has two elevon flight control surfaces attached to its trailing edge. The aft fuselage, which transfers the main engine thrust loads to the mid fuselage and ET, includes a truss-type internal structure of diffusion-bonded elements. The main engines consist of three liquid-propellant rocket engines with variable thrust. Additional data on the engines are provided in Figure 4.

2. *EXTERNAL TANK* (see Figure 5 for typical ET)

The ET has three major components which are the forward liquid oxygen (LO_2) tank, an unpressurized intertank which contains most of the electrical components, and the aft liquid hydrogen (LH_2) tank. The ET is 154.2 feet long and has a diameter of 27.5 feet and is the largest and heaviest (when loaded) subsystem of the STS. The LO_2 tank is an aluminum monocoque (shell like) structure composed of a fusion-welded assembly of preformed chemmilled gores, panels, machined fittings, and ring frames. The intertank is a steel/aluminum semi-monocoque cylindrical structure with flanges on each end for joining the LO_2 and LH_2 tanks. The intertank contains the forward SRB-to-ET thrust beam and fittings which distribute the SRB loads to the LO_2 and LH_2 tanks. The LH_2 tank is an aluminum semi-monocoque structure of fusion-welded barrel sections, five ring frames, and forward and aft ellipsoidal domes. The LH_2 tank provides, at its forward end, the ET-to-Orbiter forward attachment strut and, at its aft end, the two ET-to-Orbiter aft attachment ball fittings and the SRB-to-ET stabilizer attachment ball fittings.

3. *SOLID ROCKET BOOSTERS* (see Figure 6 for typical SRB)

The SRB's incorporate the largest solid propellant motors ever flown and the first designed for reuse. With the forward skirt, frustum, and nose fairing added, the complete SRB is just under 150 feet in length and weighs about 1,293,500 pounds. A solid propellant rocket motor consists of an insulated case, propellant, nozzle, and igniter. Because of its size and weight, the SRB is manufactured and shipped to KSC in four segments. At the launch site complex, the segments are assembled by tang and clevis joints machined into the case ends. Each joint is fastened with 177 headless, multiphase nickel chromium alloy pins installed in matching holes drilled in the tank and clevis. The pins are held in place by a retaining band around the entire circumference of the joint. The joint is sealed against pressure leaks with two synthetic rubber O-rings installed in the circumferential grooves machined in the clevis.

4. *WEIGHT AND CENTER OF GRAVITY DATA*

Dry weight data and wet weight data for STS Mission 51-L at SRB ignition on January 28, 1986, are shown in Table 1.

TABLE 1. DRY WEIGHT DATA AND WET WEIGHT DATA AT LIFT-OFF

Component	*Weight in Pounds*
• Orbiter	
• dry-with crew, w/o cargo	177,372
• wet-with crew, w/o cargo	216,494*
• wet-with crew and cargo	268,829
• External Tank	
• dry	66,933
• wet	1,663,966*
• Right Solid Rocket Booster	
• shell only	180,583
• full	1,297,849*
• Left Solid Rocket Booster	
• shell only	180,561
• full	1,297,828*
• Cargo	52,335*
• Lift-Off weight (wet)	4,528,472
• Shuttle Center of Gravity	X_s 1412.2, Y_s 0.2, Z_s 419.9

*Denotes Flight Element Weights.

E. STRUCTURAL IDENTIFICATION AND RECONSTRUCTION OF STS MISSION 51-L

When recovered STS structure was returned by ship to the docks at Port Canaveral, it was washed with fresh water and loaded onto pallets and trucks for transport to KSC or the Cape Canaveral Air Force Station where impoundment areas had been established. Access to the impoundment areas was controlled by KSC security forces on a 24-hour, 7-day per week basis. The three major impoundment areas where large enough to respectively accommodate almost the full dimensions of the STS subsystems — Orbiter, ET, and SRB's. Separate areas were established for the crew module, the SSME's, and the MPS. The impoundment area for the SRB's was located in a remote hangar (Hangar "O") near the Eastern Space and Missile Center (ESMC) Explosive Ordnance Disposal (EOD) Range on the Cape Canaveral Air Force Station because the pieces of SRB contained unburned and potentially explosive propellant.

As the wreckage arrived at the impoundment area, it was unloaded from the trucks with forklifts and transferred to the identification area. The pieces were video-taped, photographed, identified by Quality Assurance personnel, and appropriately tagged. Each piece of wreckage was assigned an identification number based on its time of arrival at the impoundment area, and a chronological record was prepared which included the identification number, description, time and date of arrival, related photograph numbers, date, time, and location (latitude and longitude) of recovery (if known), and the name of the ship that delivered the wreckage to the docks.

The impoundment areas for the Orbiter and ET were divided into 4-foot squares and marked with yellow tape. The pieces of wreckage were placed in the appropriate squares which corresponded to their full dimensional plan form location. As the quantity of wreckage increased, platforms and stanchions were constructed upon which the pieces of wreckage were placed or secured vertically. Various internal storage tanks from the Orbiter were identified and collected in one location for further examination — see Photographs 1 and 2 for layouts of the Orbiter and ET wreckage, respectively.

Pieces of wreckage that were removed from the impoundment areas for metallurgical or chemical analysis were accounted for by hand receipt. Personal cameras were excluded from all impoundment areas, and all photographs were taken by KSC photographers. Video tapes, pertinent photographs, and records of the photographs taken were kept in safes in the impoundment areas.

After transport to the EOD area/Hangar "O", the pieces of SRB wreckage were initially evaluated and identified. The pieces containing unburned propellant were then taken to the EOD range where the propellant was burned in accordance with a propellant disposal plan that was developed and tested in coordination with KSC explosive safety personnel and ESMC Safety and EOD experts. The plan provided for safe disposal of the propellant and complete protection of the evidence in the process. Records including video tapes of the propellant burning processes were maintained. Following propellant disposal, the pieces of the SRB's were returned to Hangar "O" for storage and evaluation — see Photograph 3 for SRB propellant burning setup.

F. STRUCTURAL EVALUATION OF STS MISSION 51-L

1.0 *STRUCTURAL EVALUATION OF ORBITER CHALLENGER*

1.1 General

As of May 1, 1986, approximately 30 percent of the structure of the Orbiter, Challenger, was recovered from either the sur-

Solid Rocket Booster

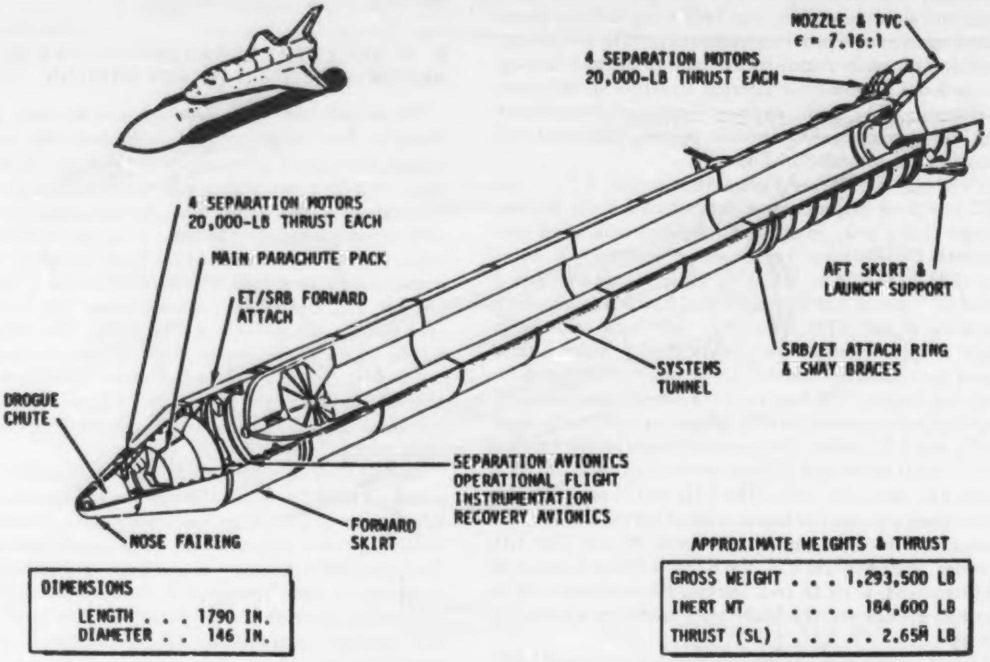
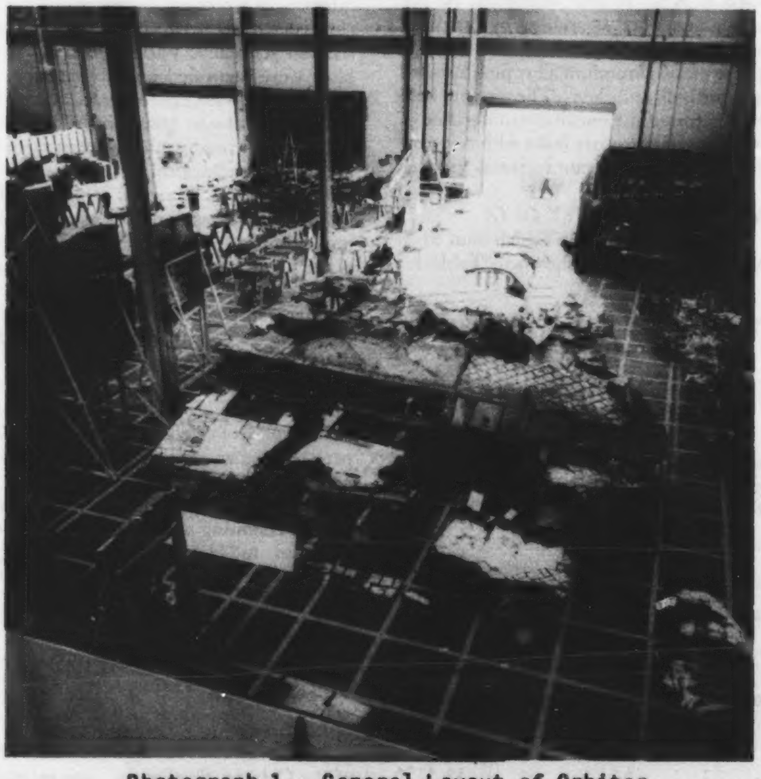
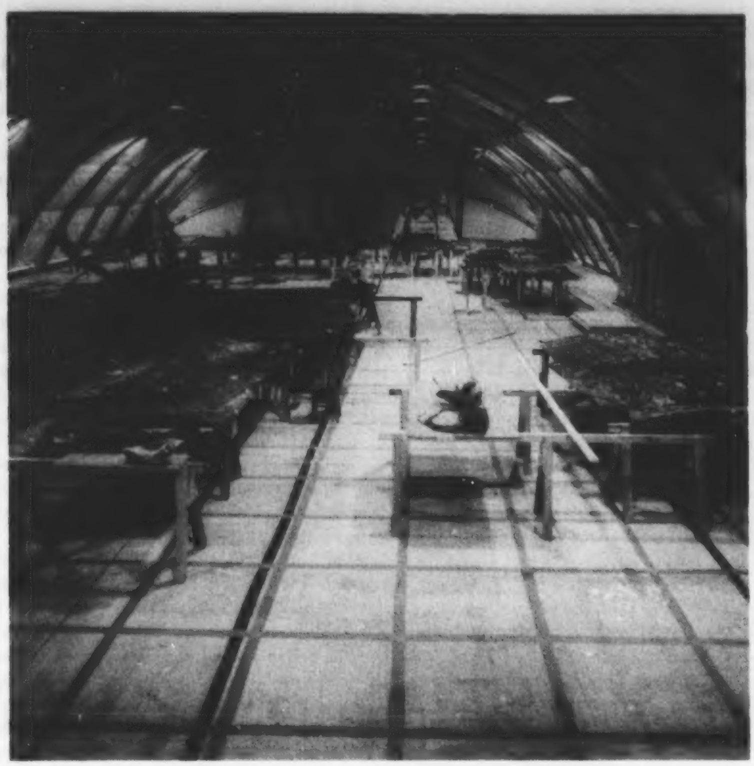

NOZZLE & TVC
ε = 7.16:1
4 SEPARATION MOTORS
20,000-LB THRUST EACH
4 SEPARATION MOTORS
20,000-LB THRUST EACH
MAIN PARACHUTE PACK
ET/SRB FORWARD
ATTACH
AFT SKIRT &
LAUNCH SUPPORT
SRB/ET ATTACH RING
& SWAY BRACES
SYSTEMS
TUNNEL
DROGUE
CHUTE
SEPARATION AVIONICS
OPERATIONAL FLIGHT
INSTRUMENTATION
RECOVERY AVIONICS
FORWARD
SKIRT
NOSE FAIRING
DIMENSIONS
LENGTH . . . 1790 IN.
DIAMETER . . 146 IN.
APPROXIMATE WEIGHTS & THRUST
GROSS WEIGHT . . . 1,293,500 LB
INERT WT . . . . . 184,600 LB
THRUST (SL) . . . . . 2.65M LB

FIGURE 6



Photograph 1. General Layout of Orbiter
Wreckage Viewed from Right Aft Corner



Photograph 2. General Layout of External Tank Pieces Viewed from Aft Looking Forward. SRB Frustums at Far End of Layout

face or the floor of the Atlantic Ocean. When recovered, most of the fracture surfaces of the metallic components were corroded to various degrees from exposure to salt water (see Figures 7 through 11 for illustrations of the portions of the wreckage recovered).

The recovered structure of the Orbiter was extensively torn, twisted, mangled, and fractured—see Photograph 4 for illustration of damage. Examination of the fracture surfaces of the metallic components was accomplished on a sampling basis because of the very large number of fracture surfaces. All of the surfaces examined exhibited characteristics of overload failure. No evidence was found of fatigue, stress corrosion cracking, or manufacturing defect.

Various components of the Orbiter were examined in detail in an attempt to determine the probable failure modes and the probable sources of various material transfers and deposits found on the components. These components include portions of the upper and lower rudder speed brake (RSB) and the vertical stabilizer, the right elevons, portions of the body flap, portions of the lower forward fuselage outer shell, major portions of the right wing, the crew module, and miscellaneous structure.

Chemical analysis of residues on the surfaces of the Orbiter were performed to help establish a breakup scenario. The interpretation of the analytical results was based on the type of residue and the expected source. This is best illustrated by the residue from the SRB exhaust.

The SRB propellant contains approximately 70% ammonium perchlorate, 16% aluminum powder, 14% binder and curing agent, and 0.1% iron oxide. During combustion, the aluminum is converted to a specific crystalline state—alpha aluminum oxide—from the high temperature of the combustion process. Alpha aluminum oxide, known as corundum, produces a rough surface finish on otherwise smooth surfaces. Furthermore, aluminum oxide produced from oxidation of aluminum at atmospheric temperatures does not have the alpha structure. Therefore, the finding of alpha aluminum oxide on the Orbiter structure is strong evidence of impingement from SRB exhaust either from the hole in the inboard circumference of the right SRB or from the nozzle of the right SRB.

Splatters that appeared to be from molten metals were also analyzed to determine their composition and to establish the source. The pieces from which the samples were taken are shown in Figures 12 through 15. A summary of the analytical results is shown in Table 2.

During the week of April 7, 1986, large portions of the Orbiter's right wing, left mid fuselage side wall, and vertical stabilizer were recovered and transported to the impoundment area for examination. The portion of right wing included the entire length of the aft spar, the outboard end of the outboard elevon, and the elevon actuators. The recovered portion of left fuselage side wall included an intact length of left main longeron from its aft attachment end at bulkhead 1307 to about 30 feet forward. The vertical stabilizer included the structure from its base to a separation point approximately 15 feet above the base.

1.2 *Orbiter Component Detail*

1.2.1 *Rudder Speed Brake (RSB) and Vertical Stabilizer*

The portion of vertical stabilizer recovered consisted of the base structure up to the lower hinge area of the lower RSB (see Photograph 4A). Portions of aft fuselage structure were still mounted to the base of the vertical stabilizer. The attachment area at the aft lower right side of the vertical stabilizer was bent forward and inward, which indicated that the stabilizer may have separated from the fuselage toward the aft and right (+y) direction.[1] The surface structure of the stabilizer was extensively covered with sea life; however, of the fractured surfaces exposed for examination, their appearances were typical of overload breaks. There was some heat discoloration around the fracture area of the stabilizer at its upper right side, and the surface paint was blistered and burned. However, the aluminum structure in this area was not melted.

The Thermal Protection System (TPS) on the right side of the stabilizer was gouged, pitted, and partially eroded in some areas due to heat and mass flow over the surface. The TPS surface of the left side of the stabilizer was relatively undamaged. The direction of the erosion and penetration marks on the right side of the stabilizer are shown in Figure 15A. A small fragment of graphite epoxy skin structure from the Orbiter Maneuvering Subsystem (OMS) pod was found among the gouge marks embedded into the surface of the TPS. Other small fragments embedded into the TPS in the same area were pieces of gold insulation and a small green clamp. These items probably came from the inside area of the right OMS pod. The damage to the right side of the vertical stabilizer appeared to have been the result of SRB exhaust impingement and high energy contact with fragments of the right OMS pod. The OMS pod most likely broke apart and fragmented as it was subjected to the blast forces of the SRB exhaust.

The upper and lower RSB's were separated from the vertical stabilizer. The left speed brake panel was also missing from the lower RSB. The TPS on the right side of the upper and lower RSB exhibited extensive erosion due to heat and mass flow over the surface in a vertical direction (+z) whereas the left side was relatively undamaged, indicating that the right side had been exposed to high temperatures—see Photographs 5 and 6. The two rotary actuator hinges in the lower right RSB failed in tension indicating the application of a large compressive load to the left (−y) on the outer surface of the RSB. The fracture surface on the top hinge was discolored from heat. Both hinges from the upper right RSB were missing, and severe crush damage to the upper aft corner indicates that following failure of the lower hinge, the RSB rotated about the upper hinge and struck the overhang of the vertical stabilizer tip. Both hinge fittings on the upper left RSB had failed in a manner indicating the application of a large lateral load to the left (−y) and an upward (+z) load. The upper aft corner on the upper left RSB was damaged severely indicating contact with the vertical stabilizer tip.

The TPS on the right side of the vertical stabilizer tip had erosion damage similar to that on the right side of the RSB, whereas the left side of the tip had relatively little damage. The fracture surface of the interface between the tip and the rear spar of the vertical stabilizer occurred from the application of a compressive force to the left (−y).

The erosion pattern on the right RSB was vertical from bottom to top (+z) at a low angle of incidence and was one of the damaged areas in which a distinct impingement direction was discernible. The erosion of the tile coating exposed the underlying silica fibers and produced a grooved appearance in the fibers with a black molten appearance and blackened fibers at the end of the grooves. These features reflect the impingement direction which is shown in Photographs 5 and 6.

The coating on the trailing edge of the tiles on the outboard surfaces of the right RSB had a rough texture that is shown in Photograph 7. X-ray diffraction analysis of these deposits showed the presence of alpha aluminum oxide.

Gray deposits with a sandpaper-like texture were also found on the right outboard tile surfaces of the vertical stabilizer tip. These deposits were removed and analyzed by X-ray Diffraction. The analysis showed the presence of alpha aluminum oxide and aluminum silicate ($Al_6Si_2O_{13}$) or mullite. The aluminum silicate and aluminum oxide were present in about equal amounts. The presence of aluminum silicate was probably due to a reaction between the molten aluminum oxide from SRB exhaust and the silica of the tile coating and/or fibers. The direction of exhaust impingement was also discernible on this component and was consistent with the bottom-to-top (+z) impingement on the RSB.

The RSB also showed various amounts of metallic material on the heavily-eroded surfaces. As shown in Table 2, iron, nickel,

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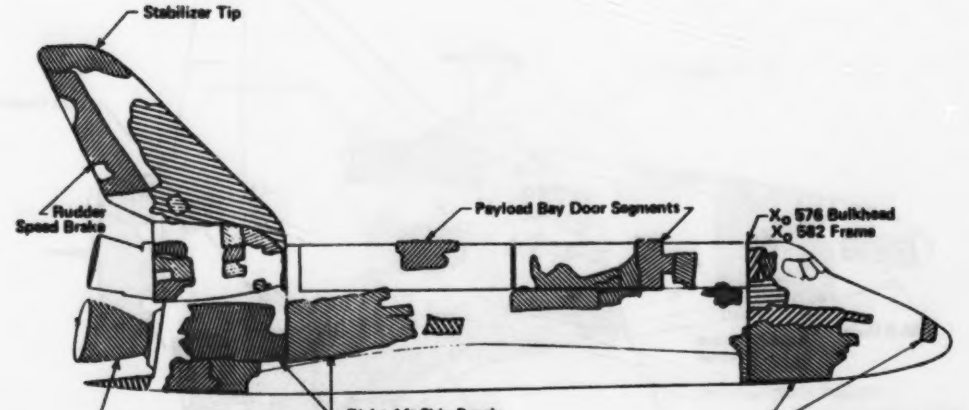
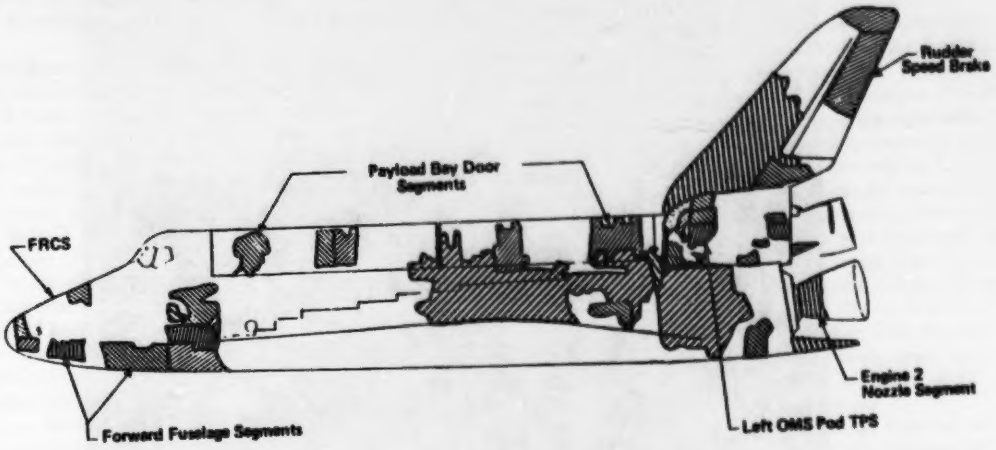
[1] Loads, forces, and directions are described with respect to the Orbiter coordinate system wherein x represents the longitudinal axis, y represents the lateral axis, and z represents the vertical axis (Figure 1).

Photograph 3. Setup for Burning Residual Propellant from Recovered Pieces of SRM


Stabilizer Tip
Rudder Speed Brake
Payload Bay Door Segments
X_o 576 Bulkhead
X_o 582 Frame
Nozzle Main Engine 3
Right Aft Skin Panels
Forward Fuselage Panels

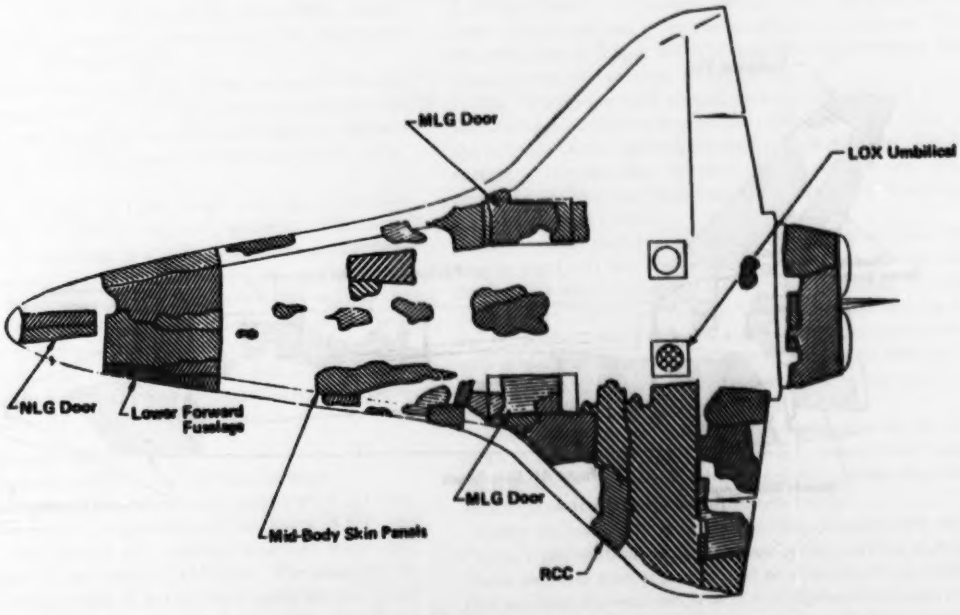
51–L
RIGHT SIDE VIEW

FIGURE 7


Rudder
Speed Brake
Payload Bay Door
Segments
FRCS
Engine 2
Nozzle Segment
Forward Fuselage Segments
Left OMS Pod TPS

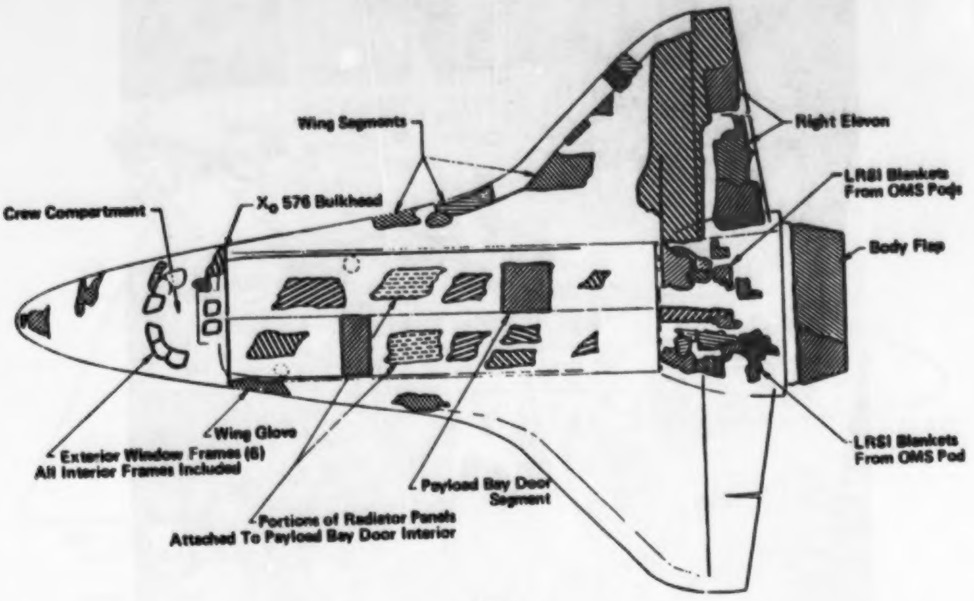
51–L
LEFT SIDE VIEW

FIGURE 8


MLG Door
LOX Umbilical
NLG Door
Lower Forward
Fuselage
MLG Door
Mid-Body Skin Panels
RCC

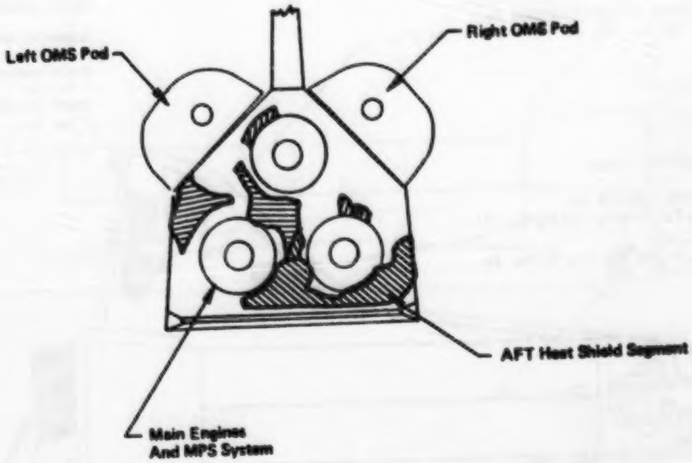
51–L
BOTTOM VIEW

FIGURE 9


Wing Segments
Right Elevon
LRSI Blankets From OMS Pods
Crew Compartment
X_o 576 Bulkhead
Body Flap
Wing Glove
Exterior Window Frames (6) All Interior Frames Included
Payload Bay Door Segment
LRSI Blankets From OMS Pod
Portions of Radiator Panels Attached To Payload Bay Door Interior

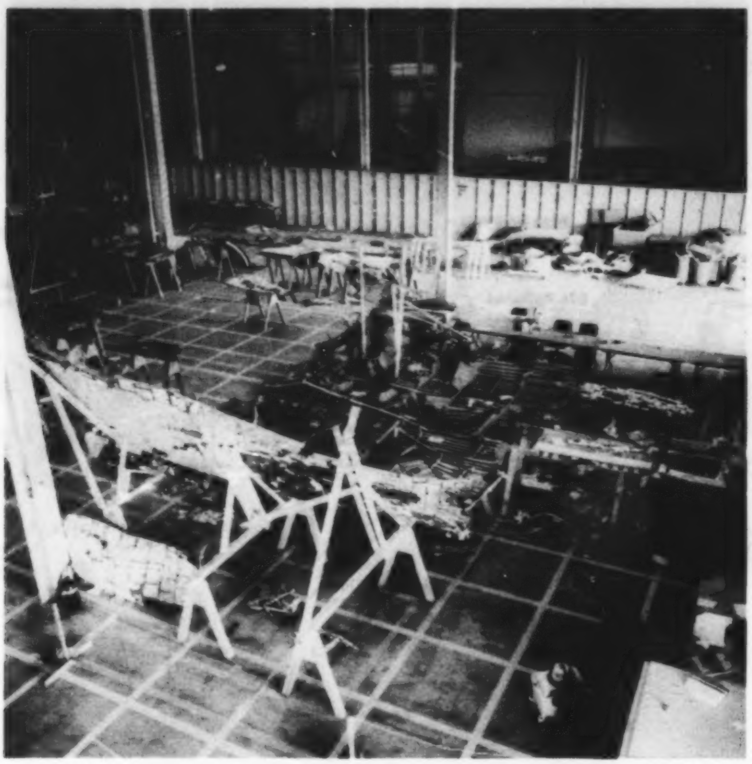
51–L
TOP VIEW

FIGURE 10


Left OMS Pod
Right OMS Pod
AFT Heat Shield Segment
Main Engines And MPS System

51–L REAR VIEW

FIGURE 11



Photograph 4. Orbiter Wreckage Viewed from Forward Right Side

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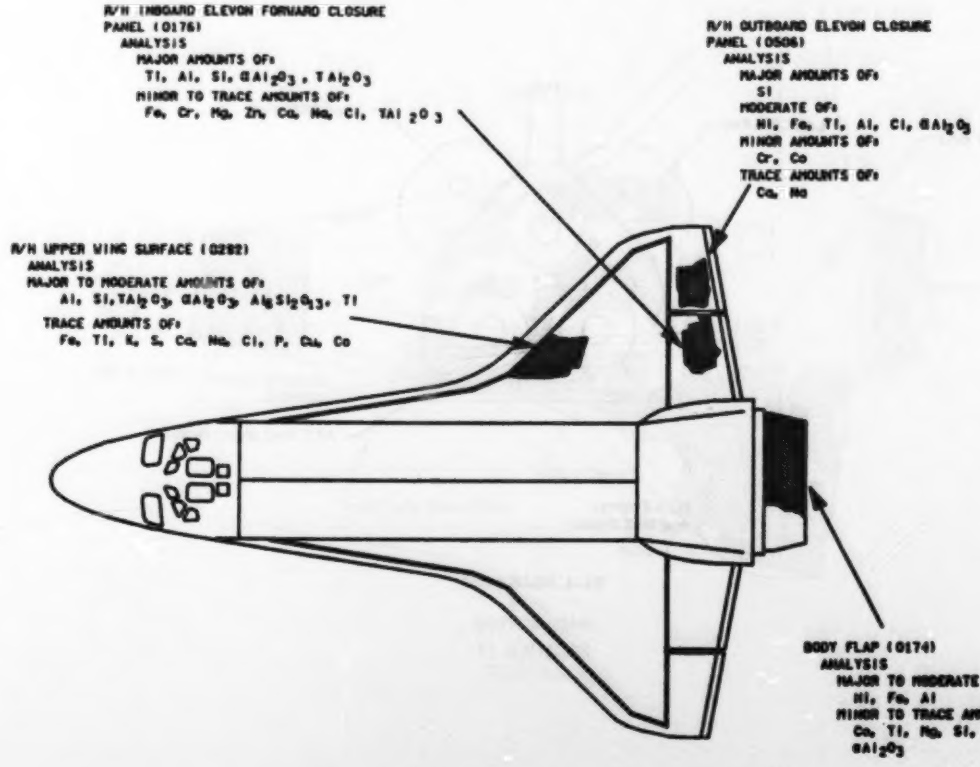

R/H INBOARD ELEVON FORWARD CLOSURE
PANEL (0176)
ANALYSIS
MAJOR AMOUNTS OF:
Ti, Al, Si, GAl_2O_3, TAl_2O_3
MINOR TO TRACE AMOUNTS OF:
Fe, Cr, Mg, Zn, Ca, Na, Cl, TAl_2O_3
R/H OUTBOARD ELEVON CLOSURE
PANEL (0506)
ANALYSIS
MAJOR AMOUNTS OF:
Si
MODERATE OF:
Ni, Fe, Ti, Al, Cl, GAl_2O_3
MINOR AMOUNTS OF:
Cr, Co
TRACE AMOUNTS OF:
Ca, Na
R/H UPPER WING SURFACE (0282)
ANALYSIS
MAJOR TO MODERATE AMOUNTS OF:
Al, Si, TAl_2O_3, GAl_2O_3, $Al_6Si_2O_{13}$, Ti
TRACE AMOUNTS OF:
Fe, Ti, K, S, Ca, Na, Cl, P, Cu, Co
BODY FLAP (0174)
ANALYSIS
MAJOR TO MODERATE AMOUNTS:
Ni, Fe, Al
MINOR TO TRACE AMOUNTS OF:
Co, Ti, Mg, Si, K, S, Ca
GAl_2O_3

Figure 12. Foreign Materials Analysis of Recovered Structure

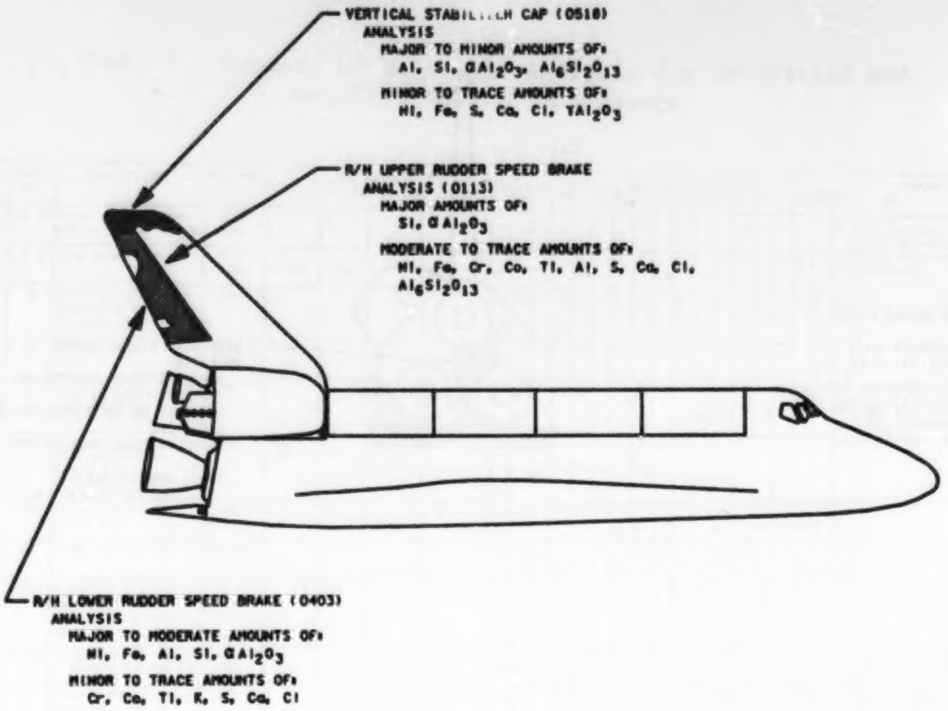

VERTICAL STABILIZER CAP (0518)
ANALYSIS
MAJOR TO MINOR AMOUNTS OF:
Al, Si, αAl_2O_3, $Al_6Si_2O_{13}$
MINOR TO TRACE AMOUNTS OF:
Ni, Fe, S, Ca, Cl, γAl_2O_3
R/H UPPER RUDDER SPEED BRAKE
ANALYSIS (0113)
MAJOR AMOUNTS OF:
Si, αAl_2O_3
MODERATE TO TRACE AMOUNTS OF:
Ni, Fe, Cr, Co, Ti, Al, S, Ca, Cl,
$Al_6Si_2O_{13}$
R/H LOWER RUDDER SPEED BRAKE (0403)
ANALYSIS
MAJOR TO MODERATE AMOUNTS OF:
Ni, Fe, Al, Si, αAl_2O_3
MINOR TO TRACE AMOUNTS OF:
Cr, Co, Ti, K, S, Ca, Cl

Figure 13. Foreign Materials Analysis of Recovered Structure

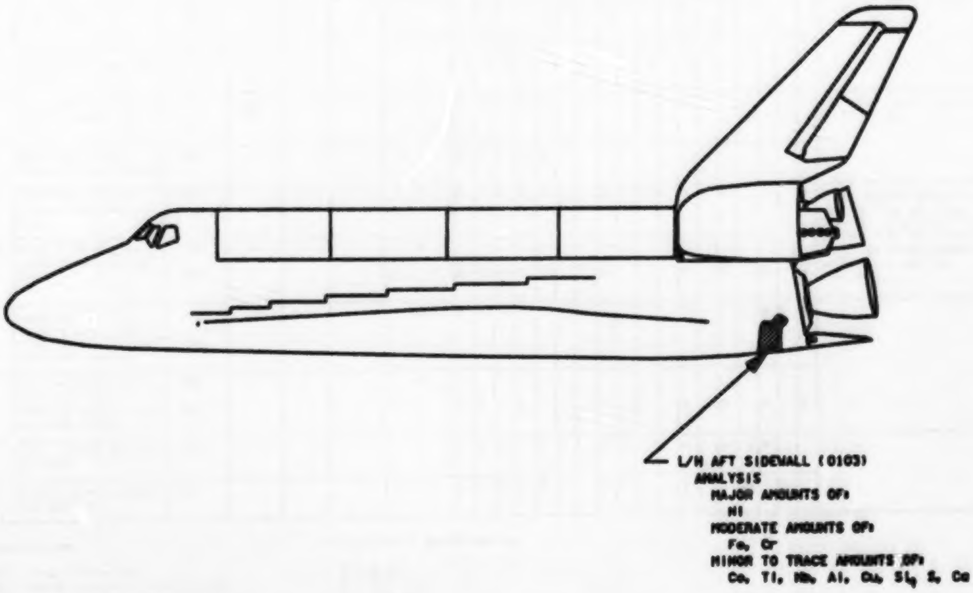

L/H AFT SIDEWALL (0103)
ANALYSIS
MAJOR AMOUNTS OF:
Ni
MODERATE AMOUNTS OF:
Fe, Cr
MINOR TO TRACE AMOUNTS OF:
Co, Ti, Nb, Al, Cu, Si, S, Ca

Figure 14. Foreign Materials Analysis of Recovered Structure

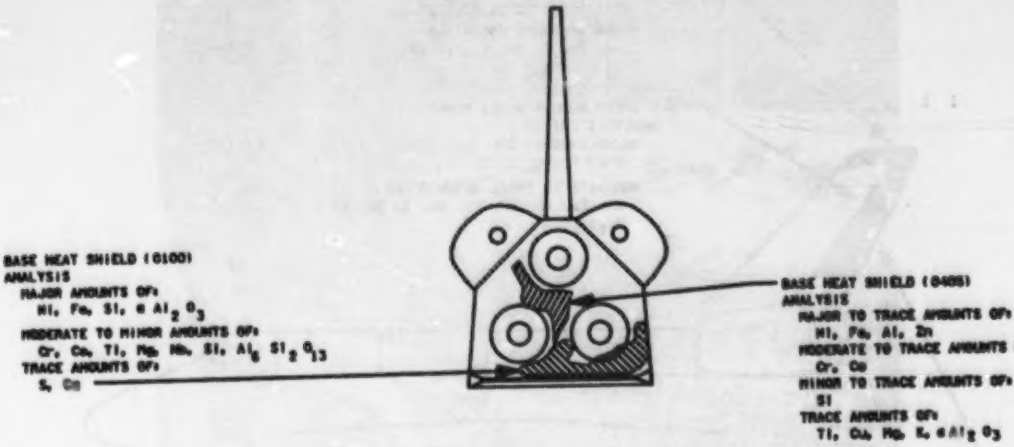

BASE HEAT SHIELD (0100)
ANALYSIS
MAJOR AMOUNTS OF:
Ni, Fe, Si, & Al_2O_3
MODERATE TO MINOR AMOUNTS OF:
Cr, Co, Ti, Mg, Mn, Si, $Al_6Si_2O_{13}$
TRACE AMOUNTS OF:
S, Cu
BASE HEAT SHIELD (0405)
ANALYSIS
MAJOR TO TRACE AMOUNTS OF:
Ni, Fe, Al, Zn
MODERATE TO TRACE AMOUNTS OF:
Cr, Co
MINOR TO TRACE AMOUNTS OF:
Si
TRACE AMOUNTS OF:
Ti, Cu, Mg, K, & Al_2O_3

Figure 15. Foreign Materials Analysis of Recovered Structure

Table 2. Summary of Materials Analysis for OV-099-SRB and Metallic Debris Impingement

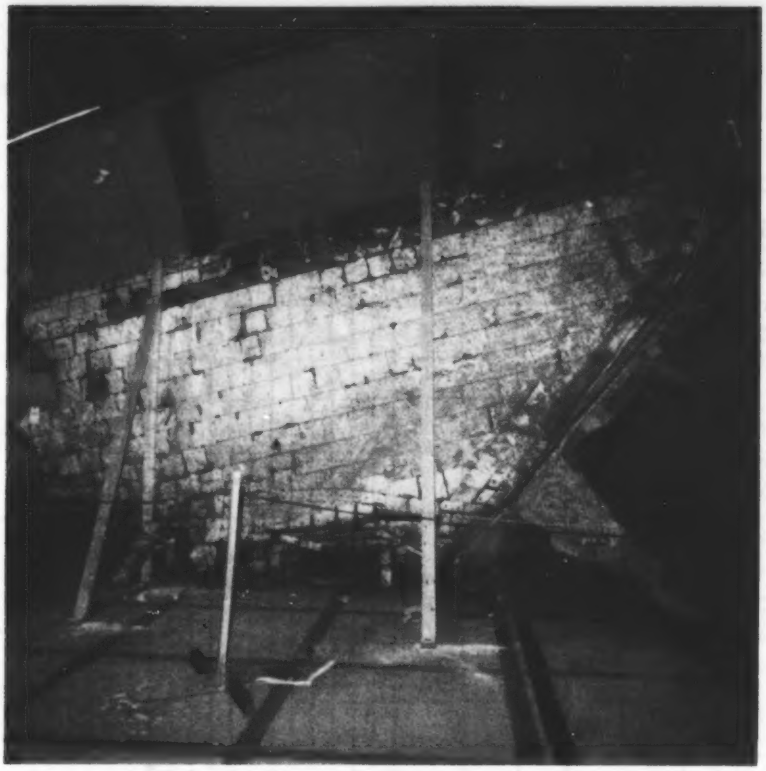
Structure	Sample No.	Description	Analyses	XRD Type Residue (XRD)				Metallic Type Debris (EDS/WDS)																		Remarks
				α-Al_2O_3	γ-Al_2O_3	δ-Al_2O_3	$Al_6Si_2O_{13}$	Ni	Fe	Cr	Co	Ti	Nb	Mg	Al	Cu	Zn	Mn	Si	K	S	P	Ca	Mo	Cl	
R/H Inboard Elevon Forward Closure Panel, Lot Item #0176	1 & 14	Black spots on Korapon surface scrapings	EDS* XRD							B		A			B										B	XRD analysis also indicates minor amounts of NaCl, $CaSO_4 \cdot 2H_2O$ and some unknown(S).
	2 & 21	Gray deposit on rib	EDS XRD	A**	C-D				D			B			A				D				B		B	
	16	White RTV with black deposit on Lower Spanwise beam	EDS							B		B		B	B		B		A		B		B	B	B	
	22	Actuator Tube	EDS XRD	A	A							A			A											
R/H Outboard Elevon Inboard Closure Panel Lot Item #0506	15	Rough eroded black tile surface. V070-193017-312	EDS					B	B	C	C	B			B				A				B	B	B	XRD analysis also indicated minor amount of metallic FCC phase.
	41	Rough eroded black tile adjacent to Sample #15, V070-193017-310	XRD	D																						
R/H Wing Upper Surface Lot Item #0292	40	Rough gray eroded white tile	XRD EDS/XRF	A	A		C	B	B	B				B	A	B			A	D	B	B	B	C	C	
	42	8"x8" Damaged FRSI	EDS/XRF					C-B	C-B	C-D	B	A			C	B			A	B	B	B	C	B	C	
	23	Loose wing leading edge tile, lot item #01062. Location unknown.	XRD EDS	B	A		A-B		B			B			A-B				A	B	D		B	B		
Body Flap, Lot Item #0174	6 & 6A	Rough leading edge tile V070-3950-14-018	WDS XRD					A-B	A-B	C	C-B	C	C	C	A-B				B						B	XRD analysis of sample 6A shows major constituent to be $FeAl_2O_4$ and some SiO_2. XRD of sample 34 shows presence of metallic FCC phase.
	8	Leading edge tile, metal splatter on smooth surface	EDS					B	B	C	C	B		B	A				B	B	B		B			
	34	Rough tile next to trailing edge, V070-395031-317	EDS XRD	C																						
	35	Smooth tile surface with metal splatter, center of body flap, V070-395013-334	EDS					B	B	B	C				A											
Base Heat Shield Lot Item #0100 and #0405	12A	Flakey black tile coating, lot item #0100	EDS XRD	A				A	A	B	B	D		B	B-D				A				D			XRD also indicates presence of FCC phase, probably Ni-base. Sample 3405 also contained NaCl & $CaSO_4 2H_2O$.
	13	Blackened silica fibers from tile	EDS XRD	A			C	A	B	B	C		C		A-B				C		B					
	0405	Two tiles eroded & rough black coating, lot item #0405	WDS XRD	B				A-B	A-D	B-D	B-D	D		D	A-B	B	A-D	D	C-B	D						
R/H Lower MSO, Lot Item #0401	7 & 7A	Blackened silica fibers from black tile	EDS XRD	D				B	D	C	D	D			B				A				B		C	XRD also indicates presence of FCC phase.
	11	Darkened silica fibers in erosion pit	EDS					B	C	C	C	B			C				A	D	D		B		C	
R/H Upper OSO, Lot Item #0113	14	Blackened silica fibers from white tile	EDS					C	C	C	B	D			D				A		B				D	Cross section analysis of coating chip 14A shows iron-rich spheres at the surface with the presence of Al becoming predominate through the coating thickness.
	14A	Black tile coating chips from trailing edge.	XRD WDS	A			B	B	B	B	C	D			B				A		B		B		D	
Vertical Stabilizer, Lot Item #01163 &	24	Loose J-Tile from leading edge. Lot item #01163. Coated with gray deposit.	XRD EDS	A-B	C-B		A-C	B	D						A-C				A-C		B		B		D	
	31	R/H vertical stabilizer cap lower trailing edge, flakes Lot item #3614	XRD EDS	B	B		A	B	B	B	B				A				A		B		B		B	
L/H Lower Aft Side-wall Lot Item #0102	9	Gold colored metallic splatter	EDS					A	B	B		C	B		B	B			B		B		D			
	10	Silver colored metallic splatter	EDS					A	B	B	B	D			B	B			B							

* Abbreviations

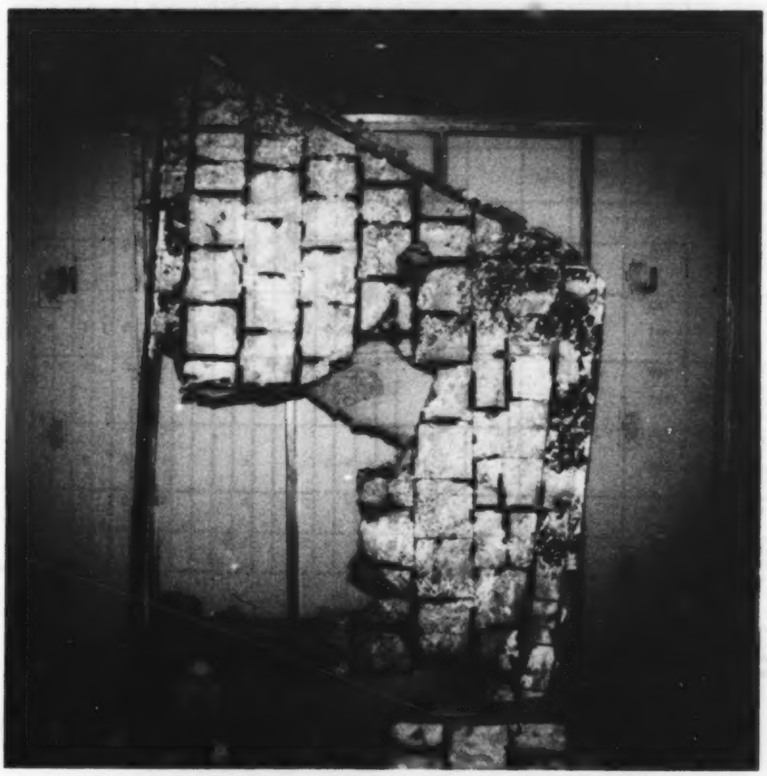
XRD - X-ray Diffraction
EDS - Energy Dispersive Spectroscopy
WDS - Wavelength Dispersive Spectroscopy
XRF - X-ray Fluorescence

** Qualitative Approximations

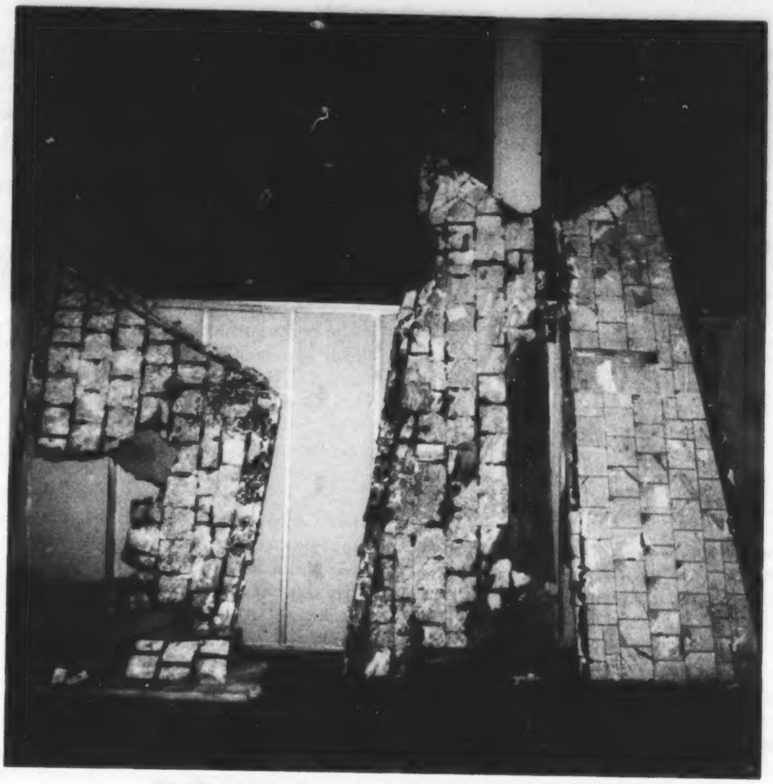
A = Major
B = Moderate
C = Minor
D = Trace



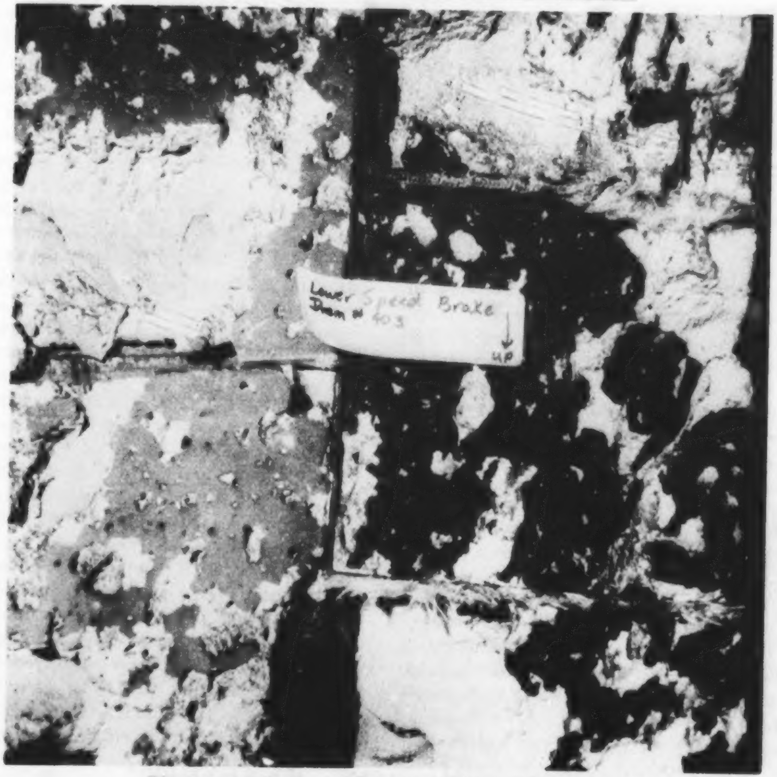
Photograph 4A. Right Side of Lower Portion of Vertical Stabilizer



Photograph 5. Right Lower Rudder Speed Brake Panel



Photograph 6. Right Rudder Speed Brake Panels, Relatively More Damaged Than the Left Upper Rudder Speed Brake Panel


Lower Speed Brake
Item # 403
UP

Photograph 7. Closeup View of Damaged Tiles of Right Rudder Speed Brake and chromium were found in all the samples analyzed from this area. In addition to these elements, smaller amounts of cobalt and titanium were identified. The metals were found predominantly in the outer surface of the deposits. The stabilizer tip residue contained the above elements, except for titanium, which was not present.

1.2.2 *Right Wing and Elevons* (See Figure 15A for typical wing structure)

A large section of right wing was recovered relatively intact and consisted of the entire aft spar at Station X_0 1307 (Photograph 7A). The lower skin surface which was still attached to these spars was essentially intact from 1365 forward to about X_0 1191. The upper skin surface was present from X_0 1365 forward to X_0 1307; however, the skin surface was collapsed downward into the wing's inner structure in several areas. An outboard portion of the outboard right elevon was still partially attached to the wing structure by one seal panel actuator tube. The upper skin surface of the attached elevon was also collapsed downward. There was no evidence of excessive heat damage on the wing structure, such as molten aluminum or heavy erosion of the TPS surfaces.

The fractures examined on the right wing structure were typical of breaks due to overload forces. The failure and bending patterns of the fractures indicated the right wing separated from the Orbiter due to an excessive positive (+ z) load on the wing. This evidence was indicated by compressive buckling at the inboard end of the wing's upper surface, upward (+ z) bending along the inboard end of the wing's lower surface, and tension failures along the lower surface of the wing. There were longitudinal indentations and crush damage in the TPS on the lower surface of the wing and elevon near the wing tips (Photograph 7B). The largest indentation mark was about 2 feet long by about 10 inches across, and was about 2 inches deep. The indentations and crush damage appeared to have been the result of an upward (+ z) contact by an external object. However, the damage did not appear substantial enough to have been caused by a force which would have created sufficient positive loads to break the wing off the Orbiter.

Examination of the elevons which had separated from the right wing of the Orbiter indicated that the outboard elevon had been subjected to a large upward force in the vertical (+ z) direction outboard of the elevon actuator. Similarly, the inboard elevon exhibited evidence of having been subjected to a substantial vertical (+ z) load. Four elevon flipper doors of titanium honeycomb showed evidence of burning which probably resulted from high-energy impact ignition of the titanium doors when the titanium clevises from the flipper door closure mechanism were forced into violent contact with the doors.

The inboard elevon forward closure panel was covered with a thin gray deposit as shown in Photograph 8. The deposit appeared almost like a paint film applied on top of the green super Koropon paint that is normally present. Removal of the deposit was accomplished by vigorous scraping of the sandpaper-like coating. X-ray diffraction analysis of the scrapings showed the presence of alpha aluminum oxide.

An additional sample of residue was taken from the elevon actuator tube. Gray deposits were present on the lower surface of this normally bare metal Inconel tube. One of the deposits was dark gray with a rough texture similar to the deposit on the forward closure panel ribs while the other deposit was a smooth lighter gray deposit. Diffraction analysis of these deposits showed both alpha aluminum oxide and the lower temperature gamma form of aluminum oxide. The significance of the gamma form is not known at this time. The right inboard elevon forward closure panel (Photograph 9) had many black splatters which appeared to originate from the top of the elevon surface. A sample removed by scotch tape showed titanium-rich spheres dispersed on the surface splatters. Other elements present in the black splatter were similar to that of the underlying super Koropon paint. Titanium metal splatters were also deposited on the elevon actuator tubes.

The tile surfaces of the inboard closure surface of the right outboard elevon also contained residue (Photograph 10). These tiles had a very rough feel and appeared to have rust and silver-colored deposits on the tile surface. Alpha aluminum oxide was found by X-ray Diffraction analysis. In addition, moderate to minor amounts of nickel, iron, titanium, aluminum, chromium, and cobalt were found.

1.2.3 *Mid and Aft Fuselage Sidewalls*

Portions of fuselage sidewall from both the left and right sides of the Orbiter were recovered for examination (see Photographs 10A and 10B). The fracture surfaces on both the left and right sidewall pieces appeared to have been the result of overload forces. The outer surface of a section of aft fuselage right sidewall was heat damaged and eroded due to heat and mass flow over the surface. The direction of flow was forward and upward at about a 50-degree angle relative to the Orbiter's x axis (see Figure 15B). The heat and erosion damage was consistent with the same type damage on the right sides of the vertical stabilizer and RSB's, and was most likely the result of exhaust blast from the right SRB.

The sidewall pieces from the left side of the Orbiter fuselage were relatively large portions of structure, and there was no evidence of heat or fire damage on the pieces. The largest piece was about 30 feet long and 12 feet high, and it consisted of payload bay sidewall structure and the upper main longeron from the 1307 bulkhead attachment area to about 30 feet forward of the 1307 bulkhead. Also recovered was the adjacent piece of fuselage sidewall normally located aft of the 1307 bulkhead. This piece was about 15 feet high and 12 feet long. The outside surfaces of this aft fuselage piece and the larger piece of payload bay sidewall structure were gouged in several areas; however, there was no apparent pattern to these gouge marks.

Three bridge fittings for support of the Inertial Upper Stage (IUS) payload remained attached to the main longeron on the large portion of left payload bay sidewall. Two trunnion retention fittings remained attached to the bridge fittings. The retention fittings were intact and in the latched position. Portions of two saddle straps for the IUS payload were still attached to the bridge fittings. Both straps were fractured at a location approximately 1 foot below the attachment pins for the straps. The fracture surfaces on the saddle straps were typical of overload failures.

1.2.4 *Crew Module* (See Figure 16 for Structure)

The crew module was found about one month after the accident at a water depth of about 90 feet and was concentrated in an area of about 20 feet by 80 feet. Approximately 75% of the crew module was recovered. Other pieces of structure also recovered from the same area included the 582 fuselage frame, portions of the forward fuselage outer shell, and all four primary attachment fittings which secure the crew module to the outer shell. The fact that much of the crew module structure was concentrated in such a small area underwater indicates that the module did not disintegrate in-flight but remained essentially intact until it struck the surface of the water. The fracture surfaces examined on pieces of the crew module were typical of breaks resulting from overload forces. There was no evidence found of heat or fire damage on the pieces of crew module recovered.

The largest fragment of crew module recovered consisted of the right half of the 576 aft pressure bulkhead (see Photograph 11). The piece was about 12 feet by 17 feet in size and consisted of the majority of the right side of the bulkhead structure and the airlock hatch. The airlock hatch was intact and secured to the bulkhead with a portion of the airlock tunnel on the forward side of the hatch. The tunnel was separated approximately 6 inches forward of the bulkhead. The remaining pieces from the left side of the 576 bulkhead were recovered and were notably more fragmented than the right side of the 576 bulkhead.

The internal crew module components recovered were crushed and distorted, but showed no evidence of heat or fire. A general consistency among the components was a shear deformation from the top of the components toward the +y direction from a force acting from the left. Components crushed or sheared in the above

Wing Structure

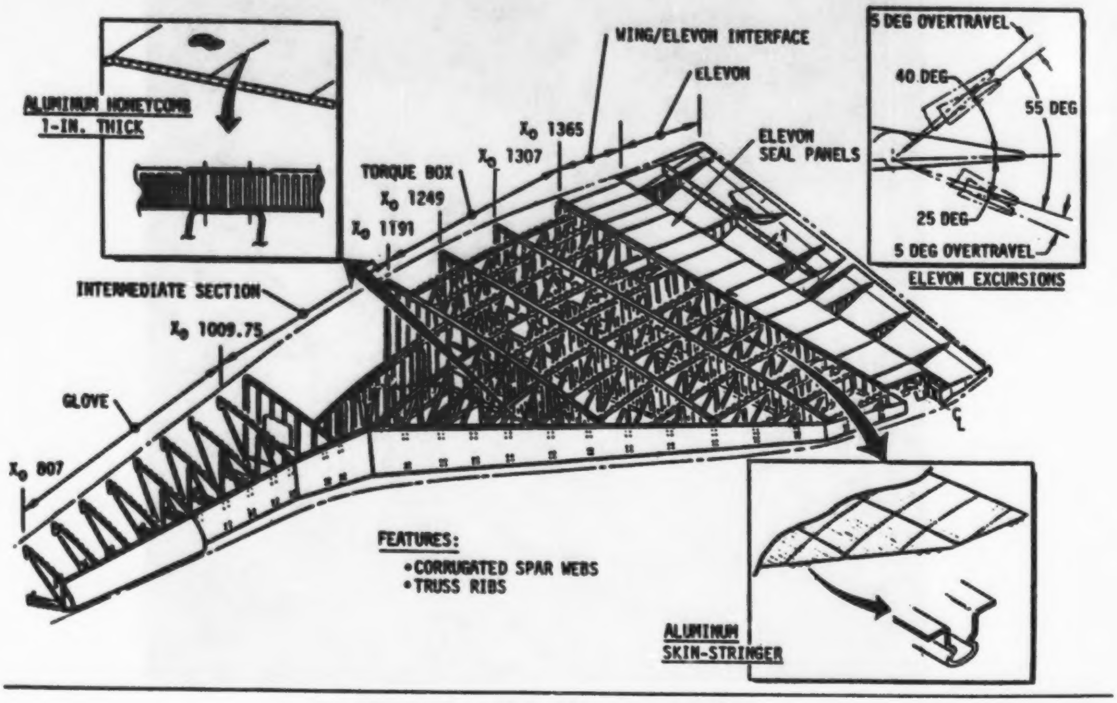
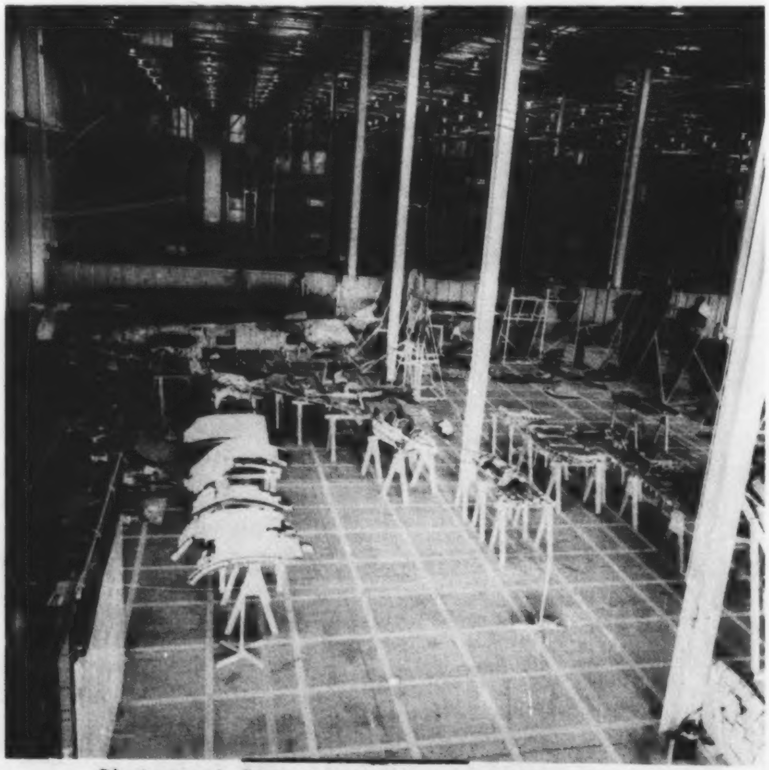
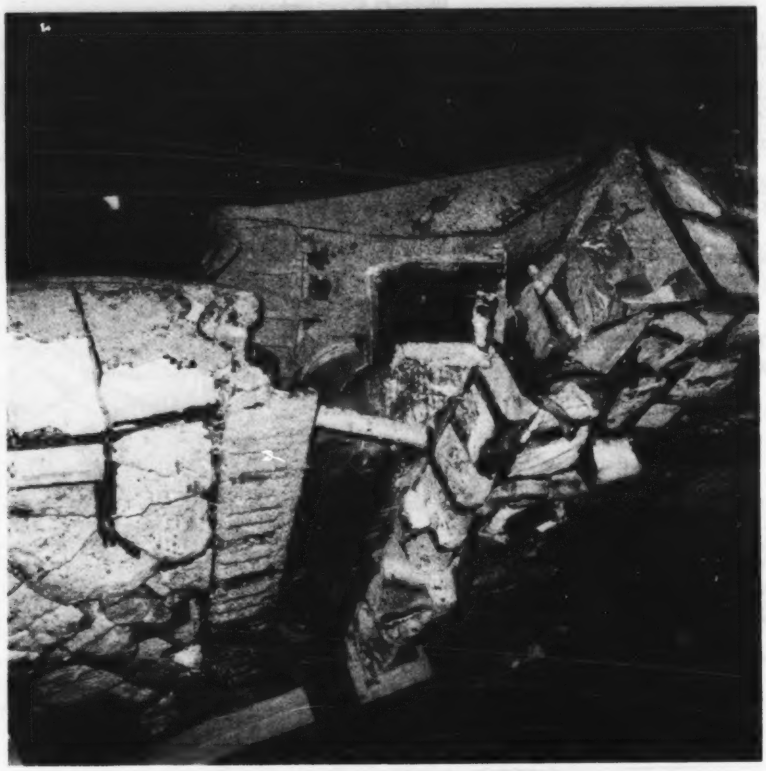

ALUMINUM HONEYCOMB
1-IN. THICK
WING/ELEVON INTERFACE
ELEVON
X_0 1365
X_0 1307
TORQUE BOX
X_0 1249
X_0 1191
ELEVON
SEAL PANELS
5 DEG OVERTRAVEL
40 DEG
55 DEG
25 DEG
5 DEG OVERTRAVEL
ELEVON EXCURSIONS
INTERMEDIATE SECTION
X_0 1009.75
GLOVE
X_0 807
FEATURES:
•CORRUGATED SPAR WEBS
•TRUSS RIBS
ALUMINUM
SKIN-STRINGER
C
L

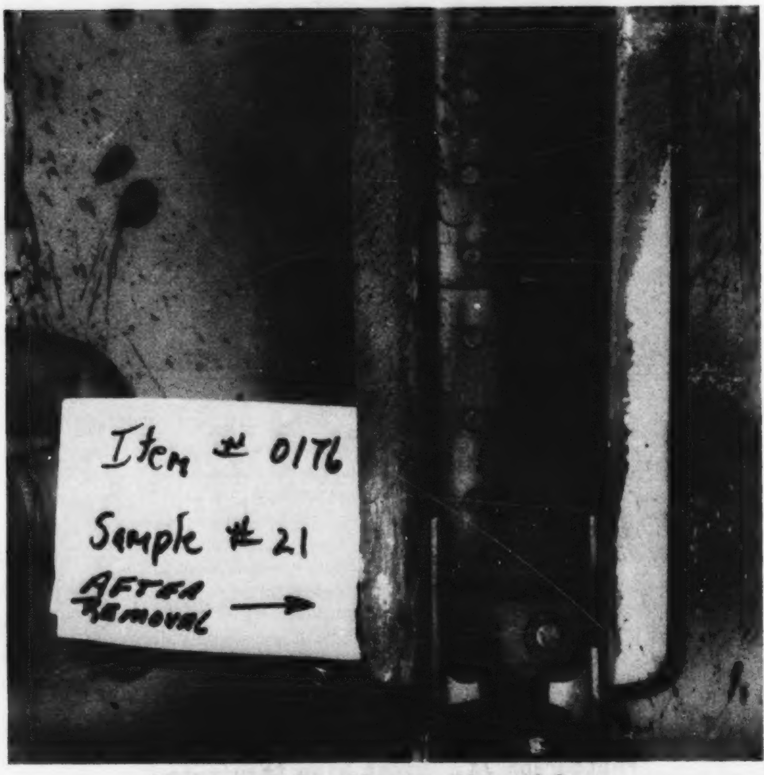
Figure 15A. Typical Orbiter Wing Structure



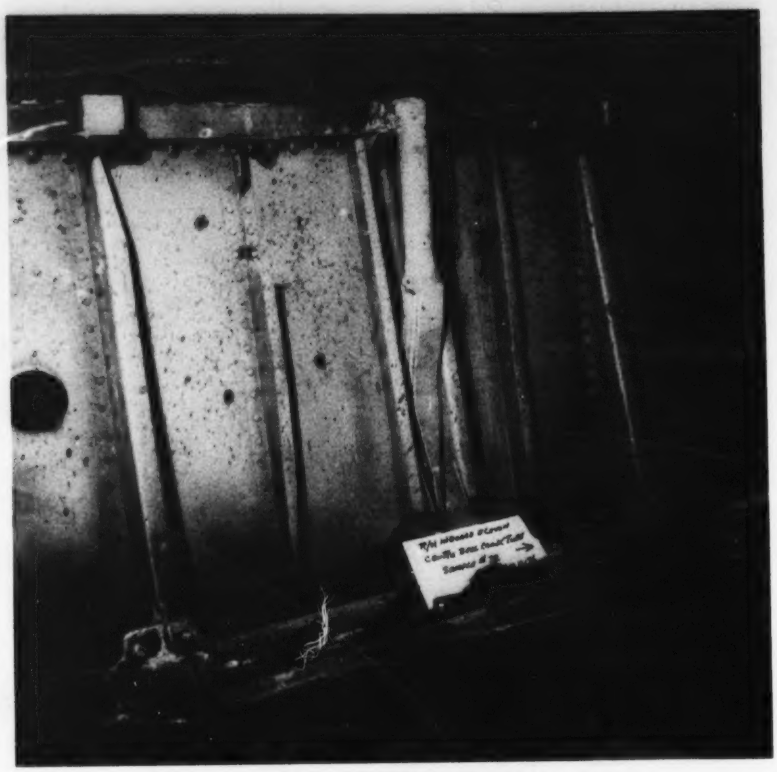
Photograph 7A, Right Wing Structure



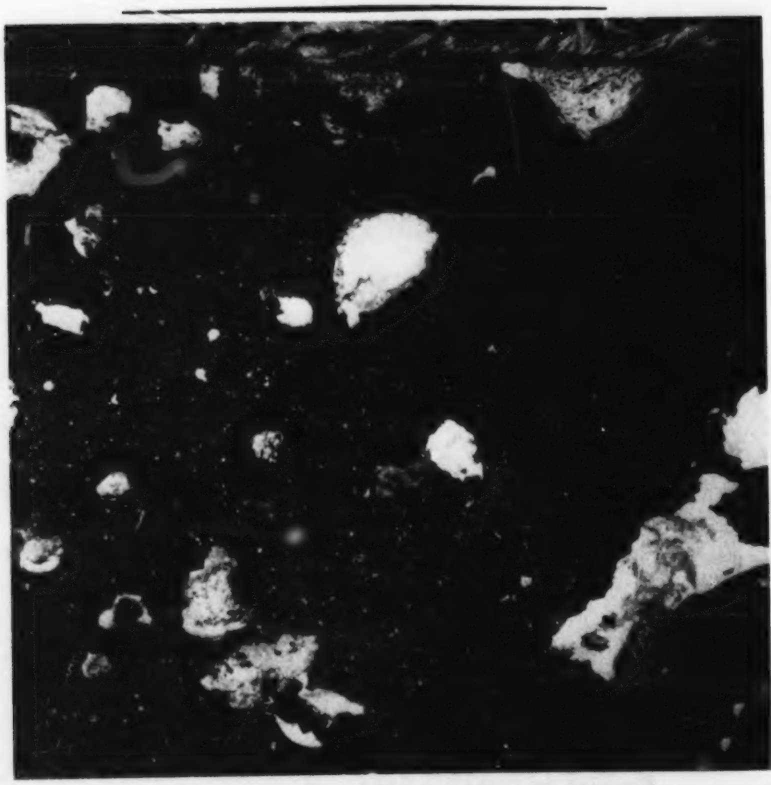
Photograph 7B. Right Wing Tip, Bottom Surface


Item # 0176
Sample # 21
AFTER REMOVAL →

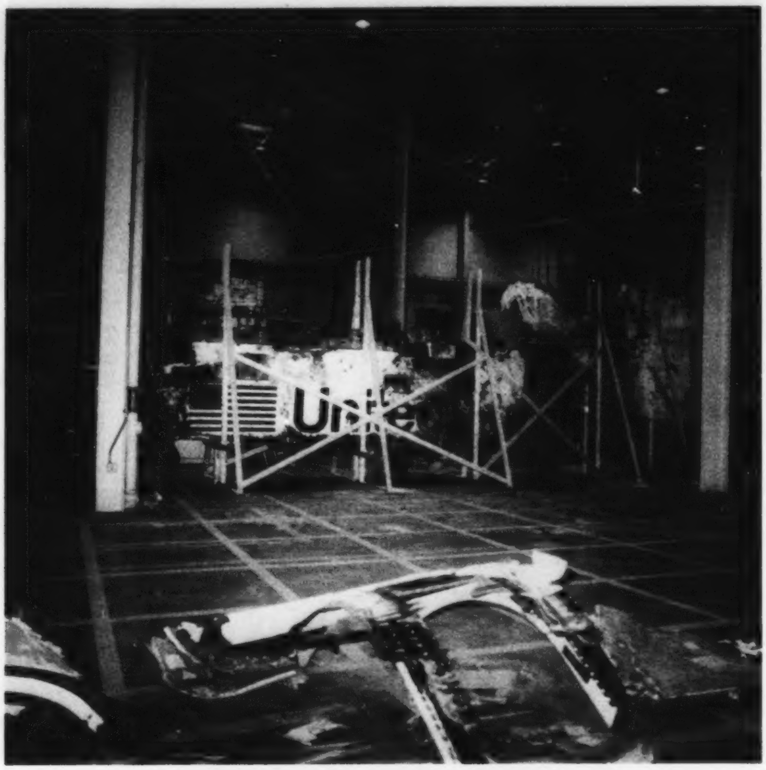
Photograph 8. Closeup View of Gray Deposits on Forward Closure Panel of Right Inboard Elevon



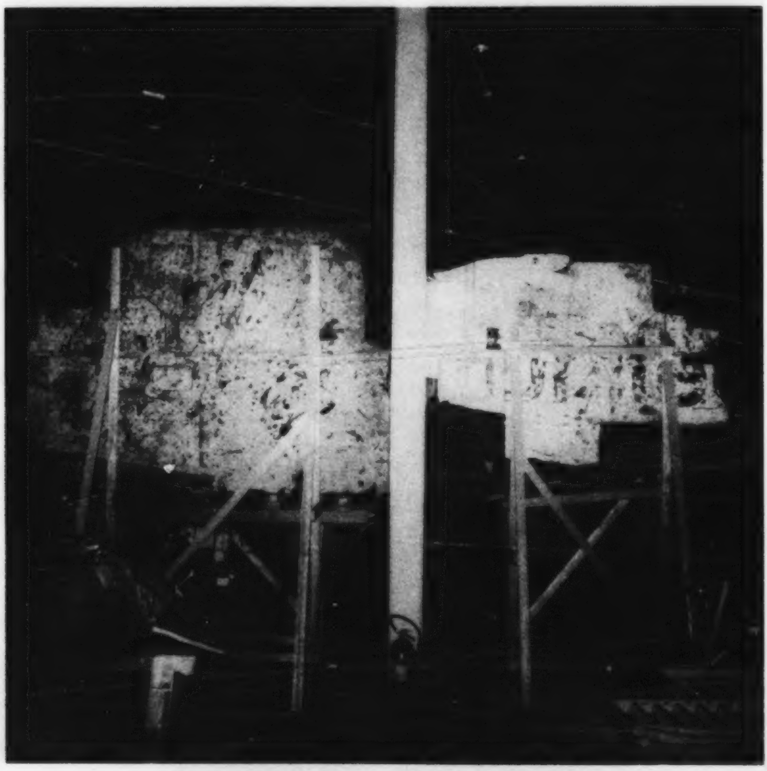
Photograph 9. Titanium Deposits on Forward Closure Panel of the Right Inboard Elevon



Photograph 10. Tile Surface of Inboard Closure Panel of Right Outboard Elevon



Photograph 10A. Left Sidewall of Orbiter



Photograph 10B. Right Sidewall of Orbiter

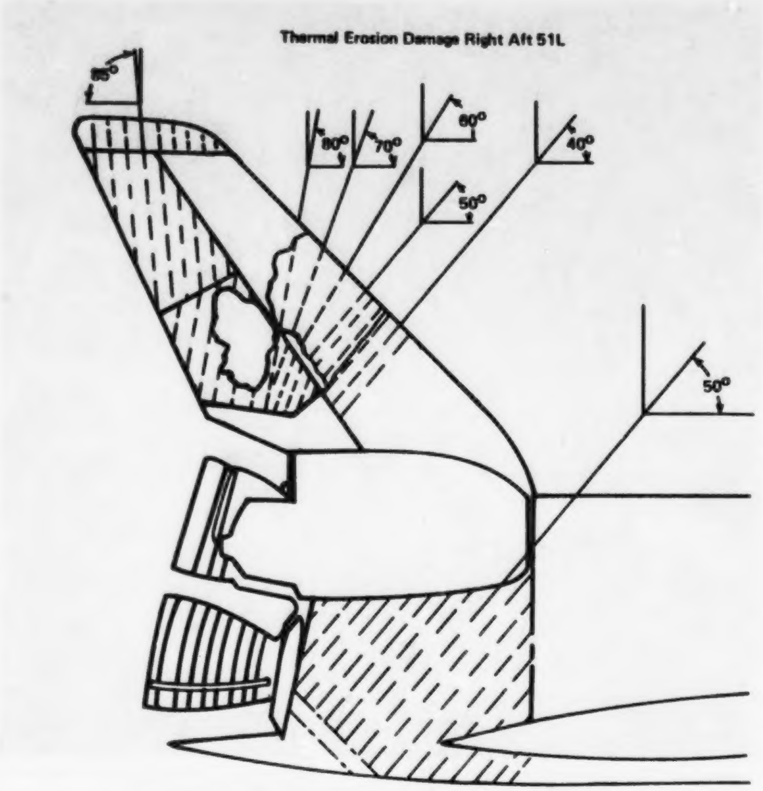

Thermal Erosion Damage Right Aft 51L
85°
80°
70°
60°
40°
50°
50°

Figure 15B

Forward Fuselage and Crew Module Structure

STRUCTURAL FEATURES: CM: FLOATING
NEAR DETERMINANT SUPPORT
WELDED (NO LEAKAGE)
INDEPENDENT ASSY & C/O

FWD FUS: SIDE HATCH SLAVED TO CM HATCH
FWD RCS CUT-OUT

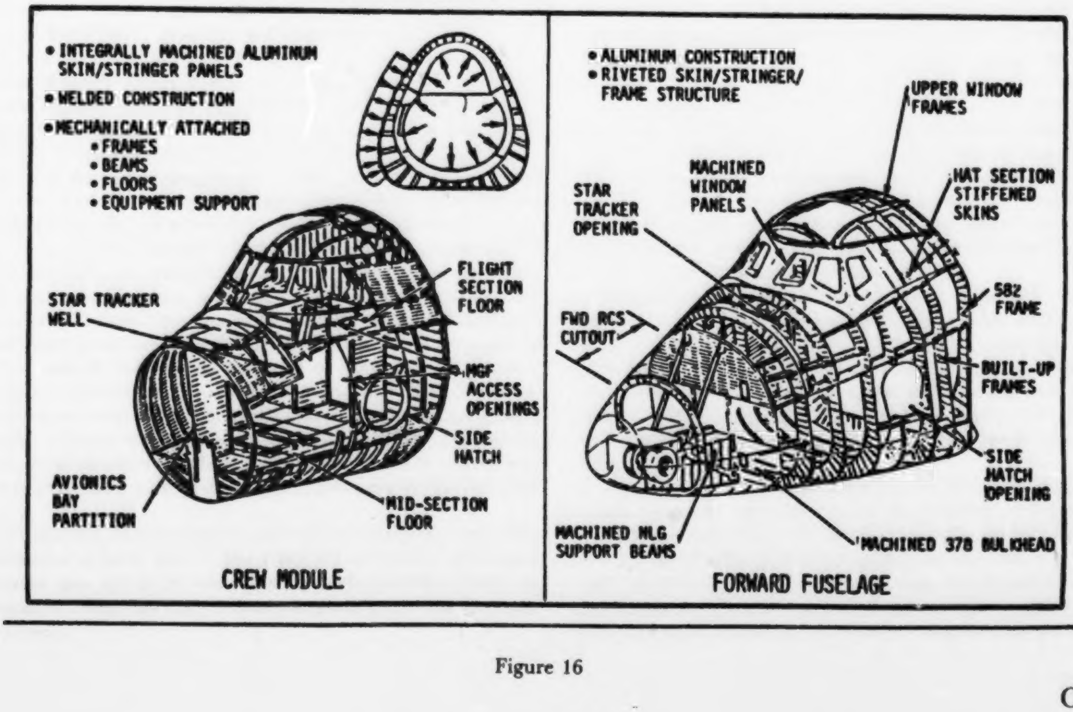

• INTEGRALLY MACHINED ALUMINUM SKIN/STRINGER PANELS
• WELDED CONSTRUCTION
• MECHANICALLY ATTACHED
• FRAMES
• BEAMS
• FLOORS
• EQUIPMENT SUPPORT
STAR TRACKER WELL
FLIGHT SECTION FLOOR
MGF ACCESS OPENINGS
SIDE HATCH
AVIONICS BAY PARTITION
MID-SECTION FLOOR
CREW MODULE
• ALUMINUM CONSTRUCTION
• RIVETED SKIN/STRINGER/FRAME STRUCTURE
UPPER WINDOW FRAMES
MACHINED WINDOW PANELS
HAT SECTION STIFFENED SKINS
STAR TRACKER OPENING
FWD RCS CUTOUT
582 FRAME
BUILT-UP FRAMES
SIDE HATCH OPENING
MACHINED NLG SUPPORT BEAMS
MACHINED 378 BULKHEAD
FORWARD FUSELAGE

Figure 16

Photograph 11. Aft Pressure Bulkhead of Crew Module, Viewed from Aft Right Side. Fuselage Frame 582 Located just Aft of Bulkhead

manner included avionics boxes from all three avionics bays, crew lockers, instrument panels, and the seat frames for the Commander and the Pilot. The more extensive and heavier crush damage appeared on components nearer the upper left side of the crew module. The magnitude and direction of the crush damage indicates that the module was in a nose down and steep left bank attitude when it hit the water.

The fact that pieces of forward fuselage upper shell were recovered with the crew module indicates that the upper shell remained attached to the crew module until water impact. Pieces of upper forward fuselage shell recovered or found with the crew module included cockpit window frames, the ingress/egress hatch, structure around the hatch frame, and pieces of the left and right sides. The window glass from all of the windows, including the hatch window, was fractured with only fragments of glass remaining in the frames.

The lower outer shell structure of the forward fuselage was recovered as floating debris on the ocean surface and was found within the first few days after the accident. Much of the outer shell (see Photograph 12) was recovered in just four major pieces. The lower outer shell separated at or just below the manufacturing interface with the upper shell. There was no evidence of burning or of significant heat damage on any of the lower shell structure. The lower shell appeared to have broken from frame 582 in one large section. The fractures along frame 582 were in tension overload with negative ($-z$) bending which indicates that the shell separated from the Orbiter mid fuselage in a nose down direction. The left side of the forward fuselage lower shell was crushed and deformed inward ($+y$) with the greatest deformation just below the side hatch frame structure. Adjacent pieces of outer shell structure from around the hatch frame were recovered with the submerged crew module. These pieces had similar crush deformation damage toward the right ($+y$) direction. The crush damage appeared typical of water impact damage. The apparent consistency of crush damage on the left side of the forward fuselage lower shell and the crew module would indicate that these two items were attached until impact with the water.

The forward ET attachment fitting plate in the Orbiter was fractured along bulkhead 378. One nut remained attached to the shaft of a bolt in the right side of the fitting plate; the bolt was fractured at a position near the underside of the fuselage skin. The aft bolt recess slot in the fitting plate was gouged in a manner which indicates that the bolt was twisted off in a clockwise direction as viewed from above toward the $-z$ direction.

1.2.5 *Miscellaneous Structures and Components*

Most of the body flap was recovered except for the four rotary actuator support fittings. The failures which occurred in the hinge fittings indicated that the body flap had been subjected to a large vertical ($+z$) load with the failures progressing from the right outboard hinge laterally ($-y$) to the left outboard hinge.

Some of the upper tile surfaces on the body flap had a sandpaper feel as well as metal impingement on them. In addition, a leading edge tile had a bubbled appearance on the coating surface. X-ray Diffraction identified alpha aluminum oxide on the upper tile surfaces. Metallic spheres with varying composition were under the bubbled area. Several were high in iron with moderate to minor amounts of chromium, nickel, aluminum, cobalt, and traces of niobium. X-ray Diffraction of the coating on this surface showed the presence of iron aluminum oxide ($FeAl_2O_4$) and quartz. The iron aluminum oxide appears to have been formed when the molten metal struck the tile surface. Other metallic splatters were primarily aluminum. Minor amounts of nickel, iron, chromium, cobalt, and trace amounts of magnesium were found. The results of this analysis are summarized in Table 2.

Portions of both main landing gear doors were recovered. The impressions of both tires on the inner surface of the right door indicates that the gear was inertially deflected downward in response to a high normal ($+z$) acceleration load while the door was closed.

Numerous storage tanks from the Orbiter were recovered as floating debris from the ocean surface—See Figure 17. Five of the tanks had various degrees of heat damage. Two metallic LH_2 tanks from the mid fuselage area were the most heavily damaged. The aluminum outer shields on each of the two tanks were partially burned away—see Photographs 13A and 13B. In their normal configuration, the two LH_2 tanks would be about 5 feet apart with the burned area of each tank facing toward the other tank. The burn patterns on the LH_2 tanks indicated that the tanks had been subjected to a sustained heat source while some LH_2 remained in the tanks. The patterns of burning and melting on the outer shields of both tanks indicate that LH_2 was present in the cooling tubes beneath the shields when the burning occurred. Consequently, the fuel for the sustained fire could have been LH_2 if an oxidizer was present or the fuel could have been the aluminum shields themselves burning in an oxygen-rich environment as the result of LO_2 leaks from the nearby LO_2 tanks or lines. From the symmetry of the burn/melt patterns on the two tanks, they must have remained secured in their normal positions, probably until impact with the water. Of the pieces of Orbiter components and structure recovered, the two LH_2 tanks were the only components/structure, except for the SSME's, that showed evidence of a sustained fire. However, there is no evidence to indicate that the fire began before the Orbiter broke apart.

The TPS tile surfaces on the base heat shield had a rough sandpaper feel with heavier deposits in the lower right quadrant near Main Engine No. 2. Analysis of the deposits in these areas confirmed the presence of alpha aluminum oxide. Blackened silica fibers where the coating on the tile was missing showed both alpha aluminum oxide and aluminum silicate (mullite). Analysis of residue taken from the tile between Engine No. 1 and No. 2 showed only traces of alpha aluminum oxide.

Analysis of molten splatters on the base heat shield showed nickel, iron, chromium, cobalt, copper, zinc, and manganese varying from major to trace depending on location of the sample. Only trace amounts of niobium and titanium were found. These findings are summarized in Table 2.

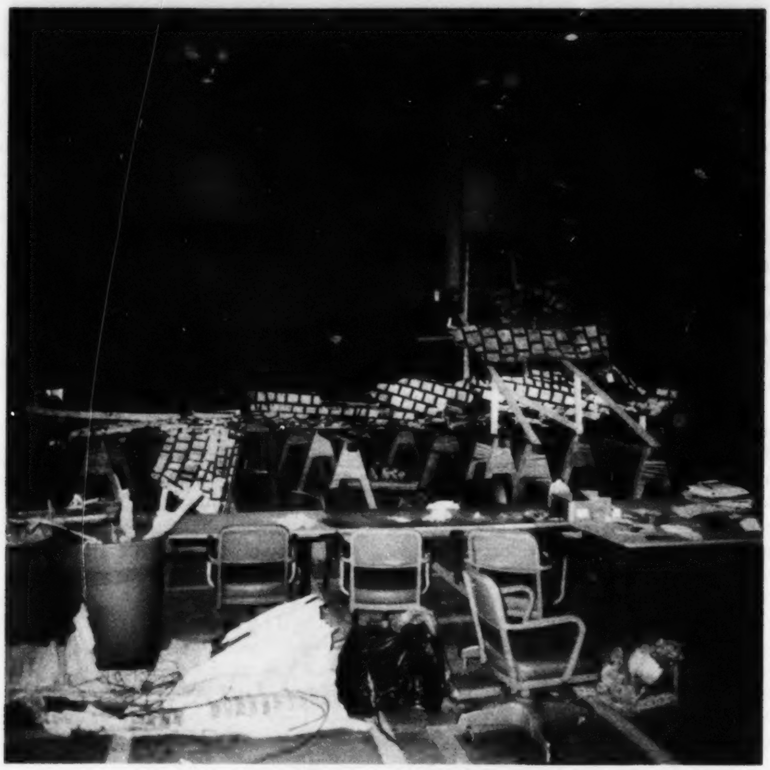
1.3 *Main Propulsion System and Space Shuttle Main Engines* (See Figure 18)

On February 23, 1986, components of the Main Propulsion System (MPS) and the three main engines (SSME's) were recovered from the floor of the Atlantic Ocean. The MPS components and the engines were in close proximity which indicates that all three SSME's probably were attached to the thrust structure (see Figure 19) upon impact with the water. The three engines were relatively intact. All metallic surfaces, except the titanium surfaces and those buried in the sand, were covered by marine life.

The gimbal bearings on all three engines apparently failed in overload, and the engine nozzles were sheared off just below the forward manifolds. All of the accessible fractures were examined and all appeared representative of ductile overload. The forward nozzle manifold, main combustion chamber, and the powerhead for each engine were attached. The six thrust vector control hydraulic actuators were attached to the engine quadropod and a segment of the thrust structure.

The powerheads on all three engines exhibited burn through damage on the two outboard fuel transfer tubes and a total loss of the line tubes on the fuel preburner sides. Also, there was extensive burn through damage on other components of each engine all of which is indicative of damage from oxygen-rich operation due to depletion of the hydrogen fuel supply. There was no evidence of heating or burning from sources other than the engines themselves.

The fuel metering valve positions on the three engines were examined to determine the phase of operation each engine may have been in when the hydrogen fuel supply was lost. For Engine 2023, Position No. 1, the fuel preburner oxidizer valve was the only valve sufficiently intact to assume that it provided a valid data position. This valve was full open, indicating that the control system for Engine 2023 was correcting for mixture ratio dur-



Photograph 12. Forward Fuselage Lower Outer Shell, Viewed from Left Side

FLUID AND GAS TANK LOCATIONS

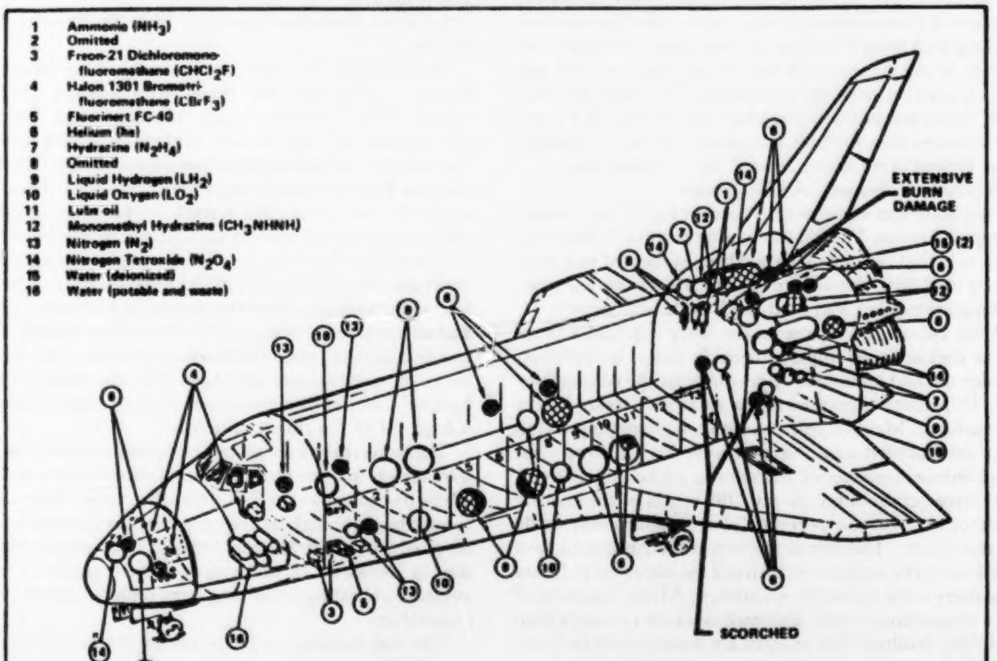
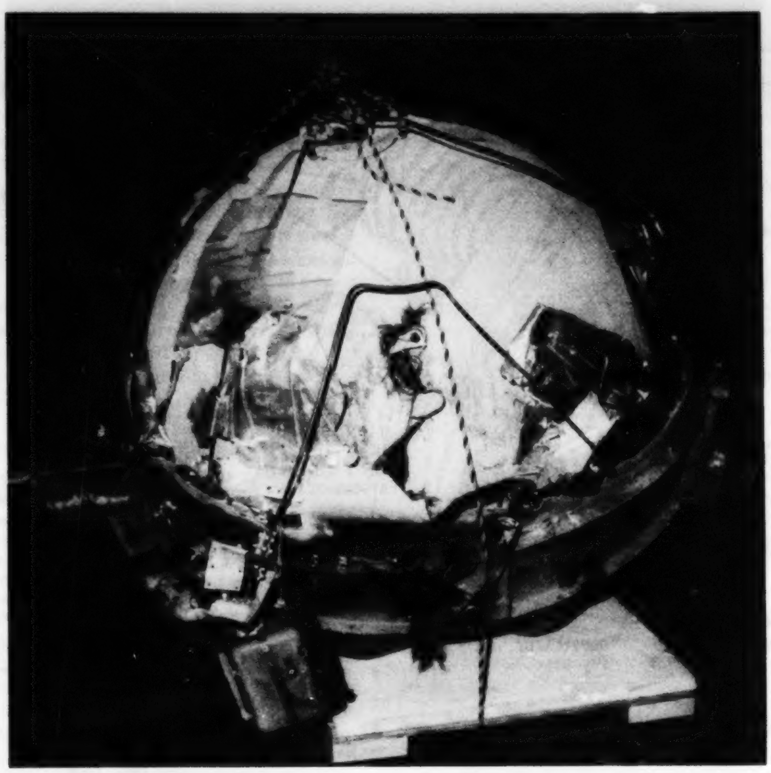
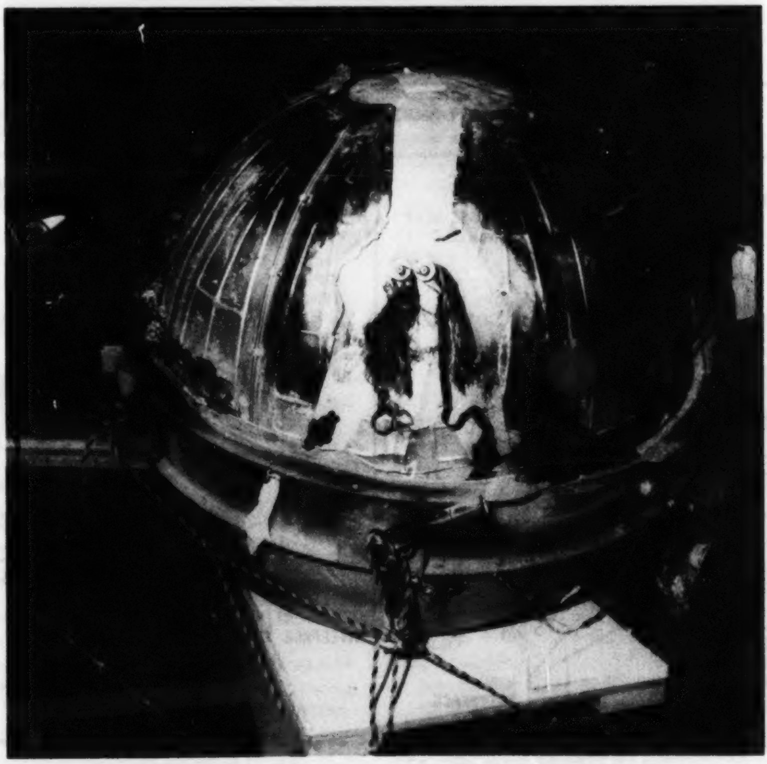

1 Ammonia (NH_3)
2 Omitted
3 Freon-21 Dichloromonofluoromethane ($CHCl_2F$)
4 Halon 1301 Bromotrifluoromethane ($CBrF_3$)
5 Fluorinert FC-40
6 Helium (he)
7 Hydrazine (N_2H_4)
8 Omitted
9 Liquid Hydrogen (LH_2)
10 Liquid Oxygen (LO_2)
11 Lube oil
12 Monomethyl Hydrazine (CH_3NHNH)
13 Nitrogen (N_2)
14 Nitrogen Tetroxide (N_2O_4)
15 Water (deionized)
16 Water (potable and waste)
EXTENSIVE BURN DAMAGE
16 (2)
SCORCHED
RECOVERED
BURN DAMAGE ON SIDES FACING EACH OTHER

figure 17



Photograph 13A. LH_2 Tank from Left Side of Mid Fuselage, Payload Bay 8



Photograph 13B. LH_2 Tank from Left Side of Mid Fuselage, Payload Bay 6

Main Propulsion Subsystem

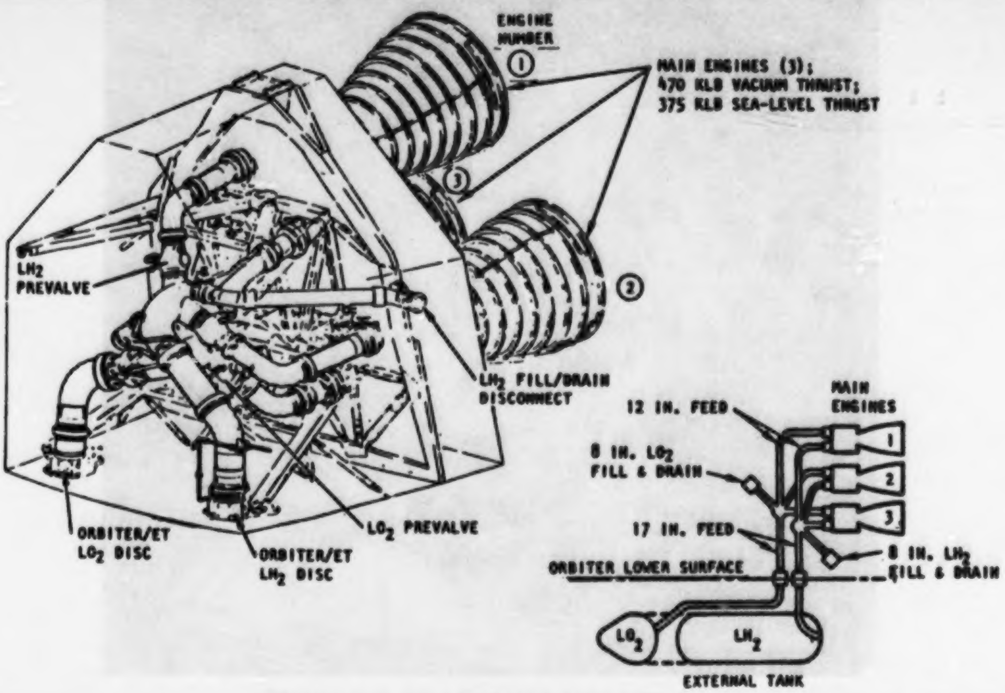

ENGINE NUMBER
①
MAIN ENGINES (3); 470 KLB VACUUM THRUST; 375 KLB SEA-LEVEL THRUST
③
②
LH_2 PREVALVE
LH_2 FILL/DRAIN DISCONNECT
ORBITER/ET LO_2 DISC
ORBITER/ET LH_2 DISC
LO_2 PREVALVE
12 IN. FEED
MAIN ENGINES
1
2
3
8 IN. LO_2 FILL & DRAIN
17 IN. FEED
8 IN. LH_2 FILL & DRAIN
ORBITER LOWER SURFACE
LO_2
LH_2
EXTERNAL TANK

figure 18

Aft Fuselage Shell and Thrust Structure

STRUCTURAL FEATURES: SHELL FULLY MACHINED FOR COST

THRUST STRUCTURE: DBT: TRUSS ELEMENTS (BORON/EPOXY REINFORCED)

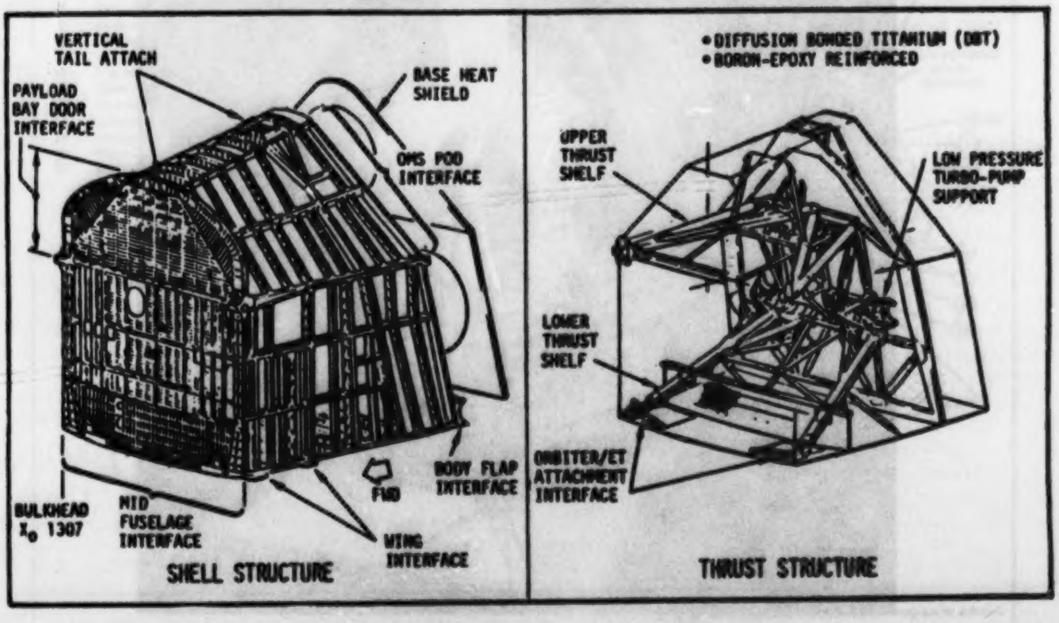

VERTICAL TAIL ATTACH
PAYLOAD BAY DOOR INTERFACE
BASE HEAT SHIELD
OMS POD INTERFACE
BODY FLAP INTERFACE
FWD
BULKHEAD X_0 1307
MID FUSELAGE INTERFACE
WING INTERFACE
SHELL STRUCTURE
• DIFFUSION BONDED TITANIUM (DBT)
• BORON-EPOXY REINFORCED
UPPER THRUST SHELF
LOW PRESSURE TURBO-PUMP SUPPORT
LOWER THRUST SHELF
ORBITER/ET ATTACHMENT INTERFACE
THRUST STRUCTURE

figure 19

ing hydrogen fuel depletion. For Engine 2020, Position No. 2, the main oxidizer valve was about 50 percent open, and the oxidizer preburner oxidizer valve was fully closed. The positions of these two valves indicate that Engine 2020 was about 1½ seconds into a computer-controlled shutdown when the hydrogen fuel supply was lost. The remaining valves of Engine 2020 were too badly damaged to provide valid data positions. For Engine 2021, Position No. 3, the main oxidizer valve and the main fuel valve were full open, and the oxidizer preburner oxidizer valve was at the mainstage position. The positions of these valves indicate that Engine 2021 was still in mainstage when it lost both hydraulics and pneumatics.

The MPS had very little evidence of burning or heat damage, but was heavily corroded by sea water and broken apart by impact forces. The components of MPS from the right side of the Orbiter were generally in better condition than those from the left side. The positions of the LO_2 and LH_2 valves in the feed lines were examined and are provided in Table 3.

1.4 *Inertial Upper Stage (IUS), Airborne Support Equipment (ASE), and Tracking and Data Relay Satellite (TDRS)*

The payload bay of the Orbiter, Challenger, contained a Tracking and Data Relay Satellite (TDRS) attached to an Inertial Upper Stage (IUS) launch vehicle, and associated Airborne Support Equipment (ASE) (see Figures 20 and 21). The combined weight of these components was about 40,000 pounds. The IUS contained two solid rocket motors (SRM's): SRM-1 and SRM-2.

A significant amount of the ASE/IUS/TDRS package was recovered from the Atlantic Ocean. Components recovered included segments of the cases of both SRM's, the ignition safe/arm device for each SRM, the ignitor for SRM-2, fragments of unburned propellant from each SRM, five explosive separation bolts that secure the two SRM's together, the forward ASE trunnions, the aft ASE trunnions with spreader beams, and an undetonated section of Super*Zip fasteners.

There was no evidence of scorching, burning, or melting on any of the components and structure recovered, and all fractures were typical overload fractures. The safe/arm device for each SRM was in the safe position, the five explosive SRM-1/SRM-2 separation bolts were intact, and pieces of propellant were not burned indicating that the SRM's had not ignited. The two aft trunnion spreader beams were intact but were bent in the downward (– z) direction. The right spreader beam was deformed about 7.5 inches and was cracked (see Photograph 14), and the left spreader beam was deformed about 1.5 inches. These deformations indicate that the ASE/IUS/TDRS package was subjected to significant inertial loads in the downward (– z) direction, while the package was intact and secure in the payload bay, as the result of positive normal (+ z) acceleration of the Orbiter.

For a complete systems evaluation of the IUS/TDRS, see IUS/TDRS Systems Working Group Final Report dated March 14, 1986.

1.5 *Probable Failure Mode (Orbiter)*

Insufficient structure was recovered to definitely establish the complete failure sequence of the Orbiter, Challenger. However, the fact that all material failures occurred from overload with no evidence of internal burn damage or exposure to explosive forces indicates that destruction of the Orbiter occurred predominantly from aerodynamic, acceleration, and inertial forces that exceeded design limits.

There is evidence that the right SRB contacted the bottom surface of the outboard section of the right wing which may have contributed to the separation of the right wing from the Orbiter. The evidence includes crush damage on the bottom surface of the right wing and outboard elevon, positive (+ z) bending and fractures in sections of the right elevon and inboard structure of the right wing, and high inertial loading on the right main landing gear and on the IUS's right spreader beam. Further, the proliferations of alpha aluminum oxide residue from molten SRB propellant on various surfaces on the right side of the Orbiter in conjunction with the approximate geometric relationship of the right wing to the inboard circumference of the right SRB during normal flight indicates that as the SRB moved upward (+ z) into contact with the right wing; and as the wing separated from the Orbiter, the right side of the Orbiter was sprayed by hot gases exhausting from the hole in the inboard circumference of the SRB. It is possible that this contact between the right SRB and the Orbiter assisted in separating the Orbiter from the ET in a rapid counter-clockwise rolling movement that exposed the Orbiter to destructive aerodynamic and inertial forces.

The structural evaluation established clearly that the crew module, including most of its outer shell, remained essentially intact until impact with the water and that the module was fragmented extensively from extreme overload and inertial forces associated with water impact. The structural deformations and fragmentations indicate that the module struck the water in a nose down and steep left bank attitude.

Evaluation of the SSME's indicated extensive internal thermal damage as a consequence of oxygen-rich operation that resulted from depletion of the hydrogen fuel supply. The positions of various engine valves indicates that the engine control system for No. 1 engine was correcting for the loss of the hydrogen fuel supply; that the No. 2 engine was in the shutdown phase; and the No. 3 engine was in mainstage operation when hydraulic and pneumatic power sources were lost. There was no evidence to indicate that SSME or MPS malfunctions or failures to the destruction of the Orbiter.

There was no evidence to indicate that the IUS contributed to premature structural failure of the Orbiter.

2.0 *STRUCTURAL EVALUATION OF THE EXTERNAL TANK (ET)*

2.1 *General*

Approximately 20% of the ET structure was recovered and the majority of these pieces were from the intertank and LH_2 tank—Photographs 15 through 18 provide illustrations of the portions of ET structure recovered. Most of the pieces recovered still had the external foam insulation material attached. Portions of the ET destruct system hardware, which included LSC's from both the LO_2 and LH_2 tanks, were recovered; the charges had not detonated.

The external foam insulation on the piece of LH_2 tank and intertank structure of the ET was scorched and discolored in various locations; however, there was no evidence of melting or burn through of the ET metallic portions of this structure. Burn patterns across the pieces of insulation on these pieces of the ET indicate that various areas were subjected to fire both before and after the ET broke up in-flight.

The fracture surfaces of the recovered pieces from the LH_2 and LO_2 tanks were examined to assess the possible modes of ET breakup. The actual failure mode of the LO_2 tank could not be adequately assessed because of the limited amount of structure recovered. However, of the LO_2 tank pieces examined, the fracture patterns were consistent with a failure due to internal overpressurization. The fracture patterns on the LH_2 tank pieces indicated that the tank broke apart due to external loads rather than an internal overpressure. The propagation of the fracture patterns indicated that the area around station X_T1871 of the LH_2 tank failed relatively early in the breakup sequence. Fractures at the aft end of the intertank near the LH_2 tank were crushed forward indicating a forward motion of the LH_2 tank relative to the intertank during the latter's disintegration.

Close examination of the ET fracture surfaces and production close-out X-rays disclosed a 0.400-inch crack-like imperfection and an area of four very small (up to 0.500-inch diameter) pores which were present before and after the flight of STS Mission 51-L. These imperfections were located along a weld line within about 2 inches of each other on the LH_2 tank near the 180 degree ($-z_0$) and X_T2060 location. This location is on the bottom side of the tank (opposite the Orbiter side) and toward the aft end. Even though the fractures propagated through the two imperfections, the directions of propagation indicated that the fractures did not originate at either of the two imperfections. Comparison of imperfection measurements as shown in X-rays before the flight with post accident imperfection measurements showed that the imperfections had not increased in size before the ET failed.

Pieces from the right circumference of the ET were examined to determine if the right SRB may have contacted the ET during the breakup. The majority of ET structure adjacent to the left and right SRB's was not recovered. However, gouge marks were noted in the integral stiffeners of the intertank thrust panel on the right side of the ET near the 70 degree and X_T1000 location (0 degrees is the + z position). A small section of thrust panel was removed from this area for chemical analysis. The analysis showed that a small amount of iron was embedded into the ET thrust panel which indicates contact with the right SRB. Examination of the right SRB frustum disclosed several gouge marks located along the 245- to 255-degree location (0 degrees is the − z position on the right SRB) on the outside circumference of the frustum base. Chemical analysis of materials extracted from the gouge marks indicated the presence of polyurethane material similar to the external foam insulation material on the ET. The distance between each of the several gouge marks on the frustum was approximately 5 inches, which corresponded to the spacing distance between the integral stiffeners of the thrust panel on the intertank. Further evidence of contact between the ET and the right SRB was exhibited by a small piece of SRB surface insulation material lodged into a fracture on the intertank skin panel near the 45-degree and X_T900 location.

Evidence of contact between the ET and the Orbiter was indicated by a small piece of TPS gap filler material from the Orbiter which was lodged into the ET near the 358-degree and X_T1130 location. The appearance of the TPS gap filler material indicated that it was from around the nose landing gear door frame area of the Orbiter. The area of the ET where the TPS gap filler material was found would be near the vicinity of the nose landing gear doors of the Orbiter when in its normal attachment configuration to the ET. Small bits of material identified as pieces of TPS tile from the Orbiter were found embedded in the ET foam insulation at various locations. The majority of locations were toward the top (+ z) side of the intertank; however, there was no discernible pattern to the embedded tile locations, and the possibility could not be excluded that some of the tile pieces may have been embedded into the ET foam insulation during wreckage recovery operations.

2.2 *Probable Failure Mode*

Insufficient structure was recovered to positively establish the failure mode of the ET. However, the structure recovered indicates that the LH_2 tank probably failed from external forces and thermal damage from the fire that erupted from the inboard circumference of the right SRB about 58 seconds after liftoff. The fire probably impinged on the ET near the lower attachment fittings for the right SRB and separated one or more of the three lower attachment fittings. The separation of the fitting(s) allowed the right SRB to twist about its single upper ET attachment fitting to the extent that the frustum joint penetrated the intertank near the 70-degree and X_T1000 location. The penetration of the intertank by the right SRB frustum probably forced the intertank structure into the LO_2 tank which permitted escape and vaporization of the LO_2.

The separations of the lower attachment fittings on the right SRB indicates that breach of the LH_2 tank preceded compromise of the LO_2 tank. The LH_2 tank probably failed from thermal damage near the welded seam that attaches the aft ellipsoidal dome to the tank cylinder. The thermally-weakened seam probably failed circumferentially under the weight of the LH_2 as magnified by longitudinal acceleration forces.

3.0 *STRUCTURAL EVALUATION OF SOLID ROCKET BOOSTERS (SRB's)*

3.1 *General*

As of May 1, 1986, 42 pieces of the two SRB's had been recovered, including 2 pieces of the right SRB (sidescan sonar Contacts Nos. 131 and 712) that identified the approximate dimensions of the hole burned through the side of the SRB near the lower field joint. Since these two pieces of the right SRB contained the physical evidence pertinent to the failure of the right SRB that initiated the accident sequence, further search and recovery efforts for pieces of SRB were discontinued as of the above date.

The frustums of both the left and right SRB's were found floating on the ocean surface shortly after the accident. The remaining pieces of SRB recovered were found on the bottom of the ocean. All recovered pieces were visually examined and selected areas were extracted for chemical and metallurgical analysis. The remainder of this report concerns all SRB pieces recovered except the two pieces of right SRB mentioned in the preceding paragraph—the evaluation of these two pieces is contained in Volume 4, Enclosure 9, of the report.

The exterior surfaces of the SRB's are normally protected from corrosion by an epoxy resin compound. There were several areas where this protective coating was gouged or missing on the pieces recovered and, as a result, the exposed metallic surfaces in the areas were corroded. The damage to the protective coating was most likely the result of detonation of the LSC's and of water impact. There was no obvious evidence of major flame impingement or molten metal found on any of the SRB peices recovered. All fracture surfaces exhibited either the characteristic herringbone or chevron markings of rapid tensile overload, a complete bending failure due to overload, or a jet-separation fracture due to the detonation of the LSC's.

Most of the SRB case material recovered contained pieces of residual unburned propellant still attached to the inner lining of the case structure. The severed propellant edges were sharp with no unusual burn patterns. Propellant recovered with a forward segment of SRB exhibited the star pattern associated with the receding shape of the propellant at the front end of the SRB. There was no evidence found of propellant grain cracking or debond on the pieces recovered. Casting flow lines could be distinguished on the propellant surfaces in several areas, which is a normal occurrence due to minor differences in the propellant cast during the installation of the propellant to the SRB case structure.

The unburned propellant which remained attached to the recovered SRB pieces was considered highly volatile and, therefore, a serious safety hazard to the evaluation process. In order to reduce this hazard, the propellant was removed by burning under controlled conditions. Thermal protection features such as vacuum putty, insulation blankets, water spray, and temperature indicators, were used to ensure that areas critical to the investigation were preserved. Photographs 19 and 20 show the condition of a recovered portion of SRB case before and after the propellant was removed.

Hardness tests of each piece of the steel casing material were taken before the propellant was burned from the piece. All of the tests showed normal hardness values.

One of the pieces of SRB casing showed evidence of O-ring seal tracks on the tang of a field joint—see Photograph 21. The tracks were cleaned with hexane to remove the grease preservative that had been applied after recovery of the piece, and samples of the track material were removed for analysis. Chemical analysis of the track material did not contain either barium sulfate or fluorinated hydrocarbon. Therefore, the tracks were not composed of degraded O-ring seal material.

3.2 *Left SRB*

3.2.1 *Left SRB Frustum*

The left SRB Frustum, which is shown in Photograph 22, was relatively undamaged except along the base where the forward skirt attached; the nose cap was missing and was not recovered. The forward booster separation motors (BSM's) were intact and unfired. The lower ring of rivet fasteners along the inner circumference of the base of the frustum were failed in a shear-type manner. Reinforcing structure, which attached to the rivets, was separated from the frustum. The shear failure of the rivet fasteners was probably the result of a pressure pulse generated by detonation of the LSC's. The drogue parachute was recovered still attached to the frustum, in good condition, and in the deployed configuration. Deployment of the drogue chute during the frustum's descent had obviously minimized water impact damage to the frustum. A 2-foot long crack at the base of the frustum was probably due to water impact and missing reinforcement structure in the frustum. There was no evidence of heat or fire damage, and all fractures on the left SRB frustum appeared to have been the result of overload forces.

3.2.2 *Left Solid Rocket Motor (SRM)* (See Figure 22)

Pieces of left SRM casing recovered included portions of the aft segment with a length of the ET attachment ring still attached. The aft center segment pieces consisted of two pieces of adjacent case structure from the 110-degree location of the forward case cylinder—see Figure 23 for SRB coordinate system. The combined dimensions of the two pieces were approximately 12 feet by 12 feet. The section of aft segment recovered was approximately 11 feet by 8 feet in dimension and contained a 180-degree section at the ET aft attachment ring—see Figure 24. The section of the ring contained none of the three ET attachment struts. A section of tang and clevis field joint was partially intact on the section of aft segment recovered. Visual examination of the fracture surfaces indicated that all breaks were the result of overload forces. Evaluation of the fracture and deformation patterns indicated that the overload forces were the results of the linear-shape charges detonated by the Range Safety Officer and of high-energy impact with the surface of the water.

3.3 *RIGHT SRB*

3.3.1 *Right SRB Frustum*

The right frustum had sustained more nose damage than the left frustum; the nose cap was missing and was not recovered. Also, the forward BSM's and housing were missing and were not recovered—see Photograph 23. The BSM and housing probably separated at impact with the water since the housing fracture surfaces were clean with no evidence of heat or erosion. The interior of the frustum sustained moderate damage to the struts and other surfaces. The fasteners at the base of the frustum which attach the frustum to the forward skirt had failed in shear similar to the failures of the fasteners on the left frustum.

There was evident and unique damage to the base of the frustum at the 240- to 255-degree circumferential location. Chemical analysis of deposits in the damaged area established the presence of polyurethane of the type used for outer insulation on the ET intertank. Also, indentations in the damaged area were spaced about 5 inches apart which corresponds to the spacing between the integral stiffeners in the ET intertank—see Photograph 24.

3.3.2 *Right Solid Rocket Motor (SRM)*

Twenty-one pieces of the right SRM were recovered, including the two pieces near the lower field joint that are evaluated in Volume 4 of the report. All of the fractures of the other 19 pieces of right SRM were typical of fractures produced by overload forces or LSC detonation. Hardness tests of these pieces indicated no abnormalities in the D6AC steel cases.

3.4 *Probable Failure Mode*

None of the 19 pieces of the right SRM or the pieces of the left SRM evaluated in this report provided indication of any structural failures that may have occurred before the SRM's were destroyed by detonation of the LSC's attached to the casings along the systems tunnel of each SRM.

G. *FINDINGS AND CONCLUSIONS*

1.0 *Findings*

a. About 30 percent of the Orbiter's total structure was recovered including about 75 percent of the crew module and surrounding forward fuselage shell structure.

b. About 20 percent of the ET was recovered; the structure was predominantly from the intertank and LH_2 tank of the ET.

c. All fractures examined on the STS structure had failed from overload forces; there was no evidence of fatigue, stress corrosion cracking, or manufacturing defect.

d. The lower structure of the LH_2 tank portion of the ET contained a minor weld imperfection; the imperfection did not contribute to the failure of the LH_2 tank.

e. There was no evidence of internal fire or explosion in the Orbiter preceding its disintegration.

f. The Orbiter was destroyed predominantly by high acceleration loads, high inertial load, and adverse aerodynamic forces.

g. Following separation of one or more of its lower attachment fittings to the ET, the right SRB struck the lower outboard portion of the Orbiter's right wing contributing to the separation of the wing from the Orbiter.

h. The aft right side of the Orbiter was burned by hot propellant gases exhausted probably from the hole in the inboard circumference of the right SRB.

i. The SSME's were functioning properly until the LH_2 supply was terminated by the failure of the LH_2 tank and/or tank connections of the Orbiter.

j. There was no evidence of malfunction or failure of the ASE/IUS/TDRS package in the Orbiter's payload bay before the right SRB forcefully contacted the Orbiter's right wing.

k. The crew module separated from the Orbiter at frame 582; the aft pressure bulkhead (576) remained with the crew module.

l. The crew module and surrounding forward fuselage shell structure forward to bulkhead 378 descended to the surface of the Atlantic Ocean essentially intact; these structures probably struck the surface in a nose down and steep left bank attitude.

m. The crew module and forward fuselage structure disintegrated from high deceleration and inertial forces associated with water impact.

n. The base of the right SRB frustum penetrated the intertank structure of the ET following release of one or more of the SRB's lower attachment fittings to the ET.

o. The LO_2 tank in the ET probably was breached by intertank structure which permitted LO_2 to escape and vaporize in the relatively warm atmosphere.

p. Fragmented LO_2 structure may have been burned by vaporized LO_2 following failure of the LO_2 tank.

q. The LH_2 tank in the ET probably failed from external forces and thermal damage near the aft ellipsoidal dome.

r. The pieces of SRB evaluated in this report were unremarkable; all fractures were from overload or from detonation of LSC's.

2.0 *Conclusions*

a. There is no evidence that structural failures in either the Orbiter or its payload package preceded the destruction of STS 51-L.

b. The Orbiter's MPS and SSME's functioned properly and did not contribute to the loss of STS 51-L.

c. The Orbiter's crew module was essentially intact until it struck the surface of the Atlantic Ocean; the crew module was disintegrated by water impact forces.

d. The ET probably failed from thermal and structural damage near the base of its LH_2 tank and from overpressurization of its LO_2 tank following partial separation of the right SRB from the ET.

POSITIONS OF LH_2 AND LO_2 FEEDLINE VALVES

LINE	ENGINE	VALVE	POSITION	REMARKS*
LH_2	1	PREVALVE (PV4)	CLOSED	DAMAGED
		RECIRC (PV 14)	CLOSED	
	2	PREVALVE (PV5)	OPEN	
		RECIRC (PV15	UNDETERMINED	DAMAGED
	3	PREVALVE (PV6)	OPEN	
		RECIRC (PV16)	CLOSED	
	N/A	FILL/DRAIN (PV11)	80% CLOSED	
LO_2	1	PREVALVE (PV1)	CLOSED	DAMAGED (ACTUATOR OPEN)
	2	PREVALVE (PV2)	OPEN	
	3	PREVALVE (PV3)	OPEN	
	N/A	INBOARD FILL/DRAIN	OPEN	DAMAGED (ACTUATOR CLOSED)
		FLAPPER (PD-1)	80% CLOSED	DAMAGED

*DAMAGED MEANS VALVE POSITION IS INVALID DUE TO IMPACT DAMAGE

TABLE 3

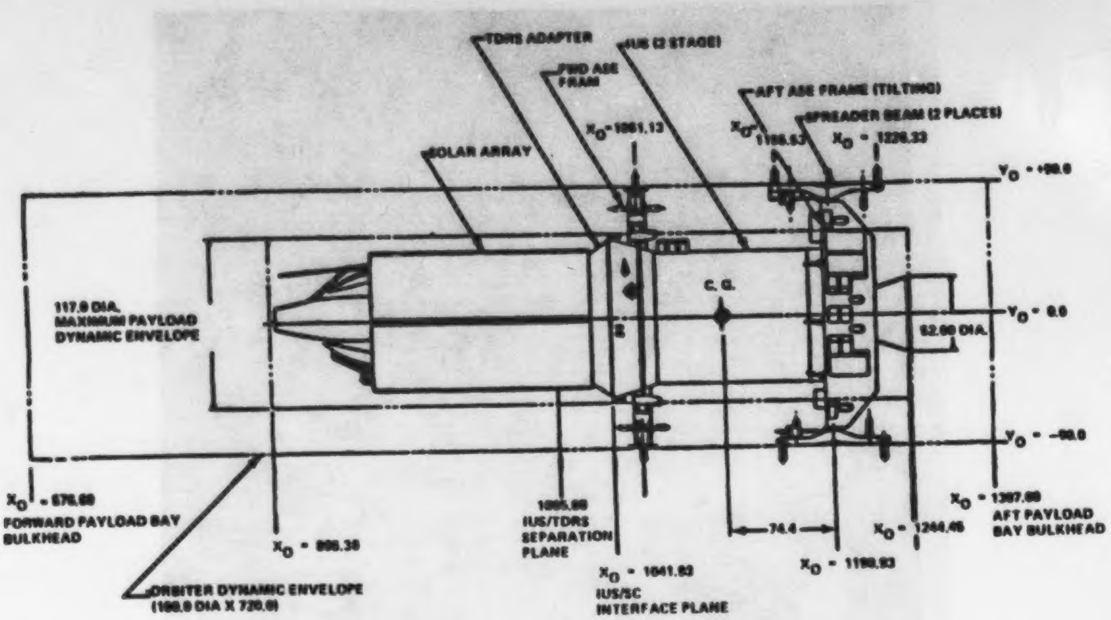

TDRS ADAPTER
IUS (2 STAGE)
FWD ASE FRAM
X_O = 1061.13
AFT ASE FRAME (TILTING)
SPREADER BEAM (2 PLACES)
X_O = 1166.57
X_O = 1226.33
SOLAR ARRAY
Y_O = +90.0
117.0 DIA. MAXIMUM PAYLOAD DYNAMIC ENVELOPE
C. G.
Y_O = 0.0
52.00 DIA.
Y_O = −90.0
X_O = 576.00
FORWARD PAYLOAD BAY BULKHEAD
X_O = 806.38
1005.00
IUS/TDRS SEPARATION PLANE
X_O = 1041.83
IUS/SC INTERFACE PLANE
74.4
X_O = 1190.93
X_O = 1244.45
X_O = 1307.00
AFT PAYLOAD BAY BULKHEAD
ORBITER DYNAMIC ENVELOPE (180.0 DIA X 720.0)

Figure 20. ASE/IUS/TDRS Configuration (Top View)

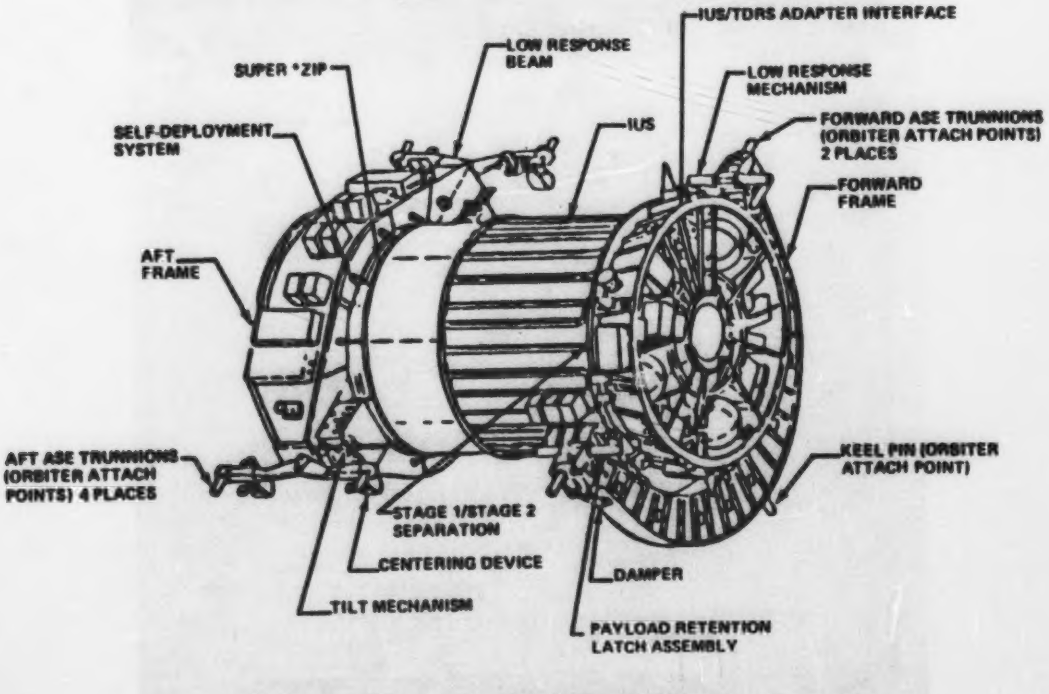
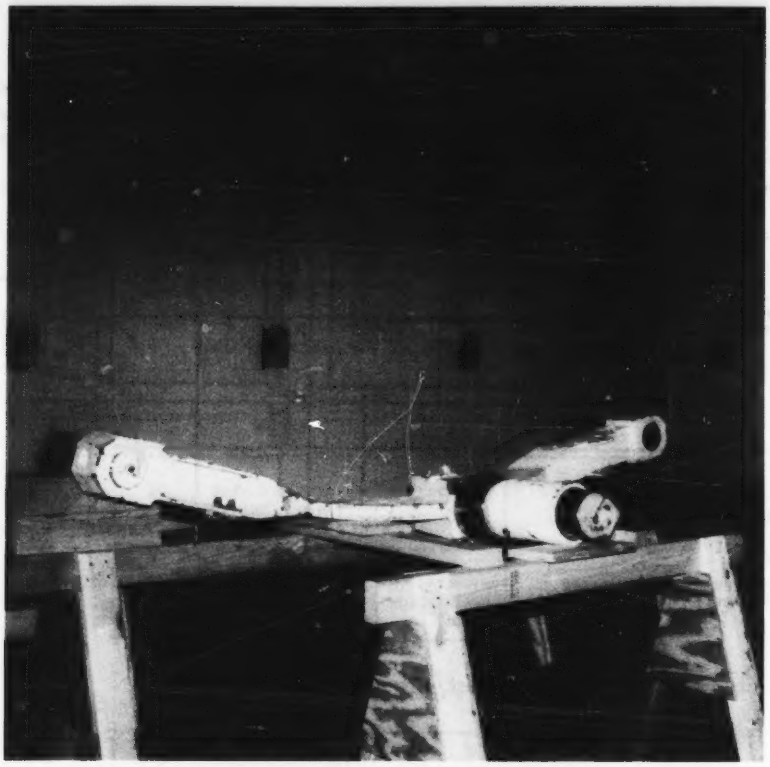
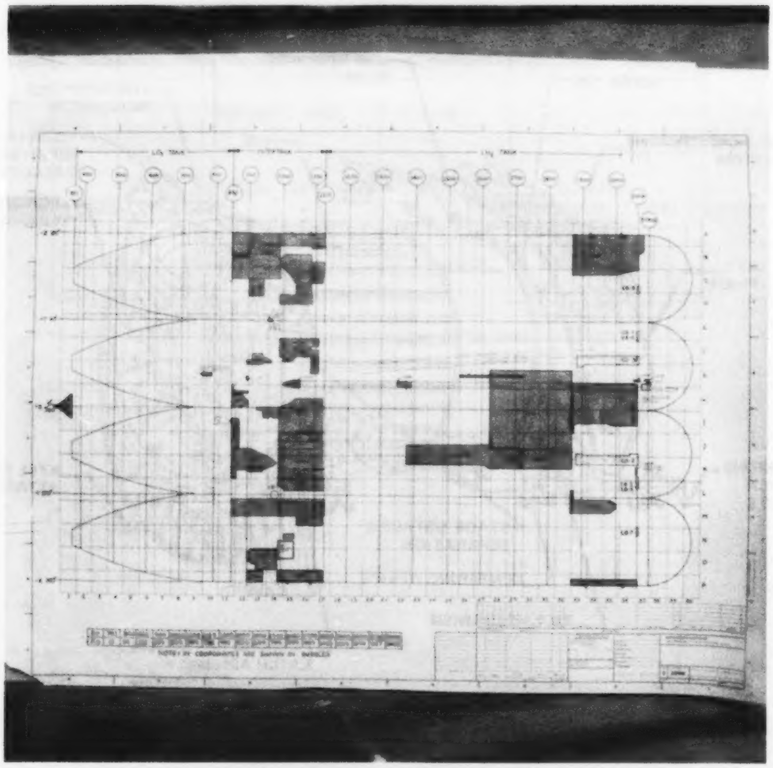

IUS/TDRS ADAPTER INTERFACE
LOW RESPONSE BEAM
SUPER *ZIP
LOW RESPONSE MECHANISM
SELF-DEPLOYMENT SYSTEM
IUS
FORWARD ASE TRUNNIONS (ORBITER ATTACH POINTS) 2 PLACES
FORWARD FRAME
AFT FRAME
AFT ASE TRUNNIONS (ORBITER ATTACH POINTS) 4 PLACES
KEEL PIN (ORBITER ATTACH POINT)
STAGE 1/STAGE 2 SEPARATION
CENTERING DEVICE
DAMPER
TILT MECHANISM
PAYLOAD RETENTION LATCH ASSEMBLY

Figure 21. IUS-3 Vehicle and ASE

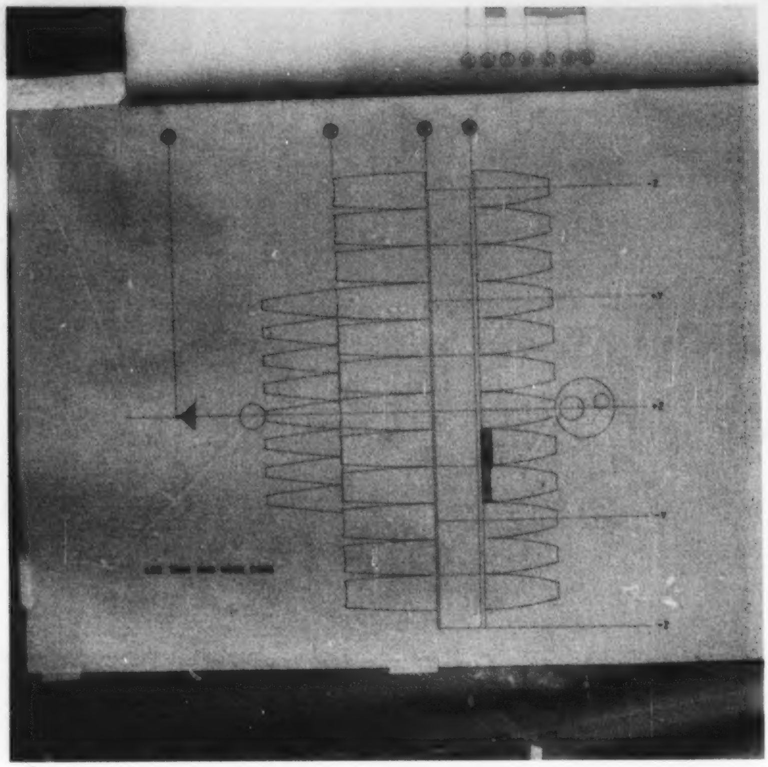


Photograph 14. Right Spreader Beam for the IUS/TDRS

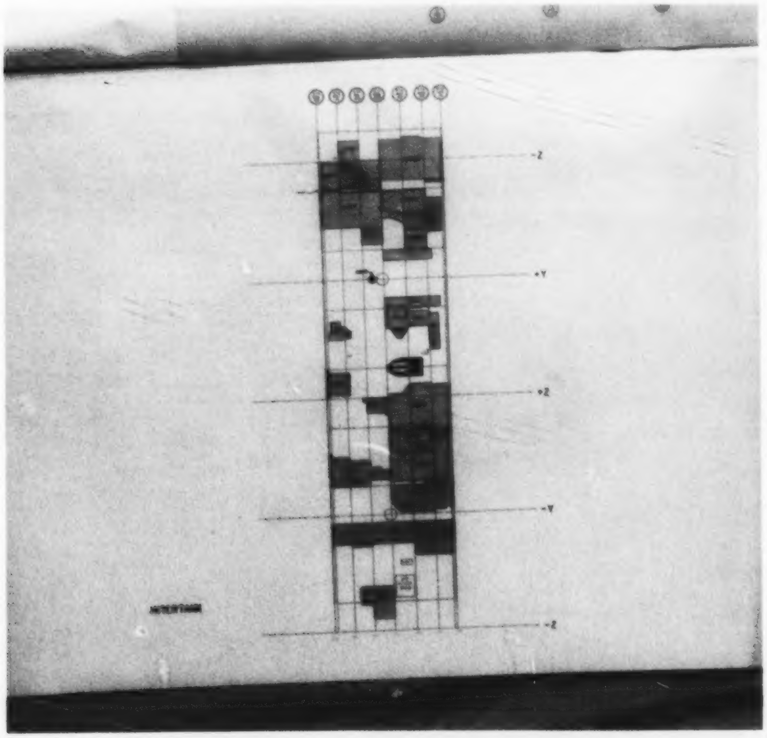


LO2 TANK
INTERTANK
LH2 TANK

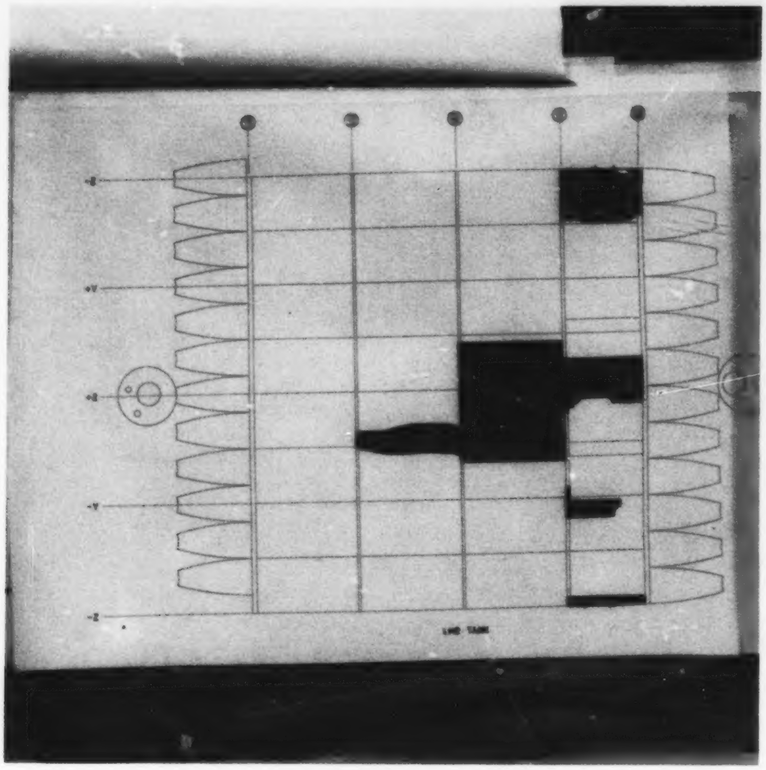
Photograph 15. Drawing of Location of ET Pieces Recovered



Photograph 16. Drawing of LO_2 Portions of ET Recovered


-Z
+Y
+Z
-Y
-Z
INTERTANK

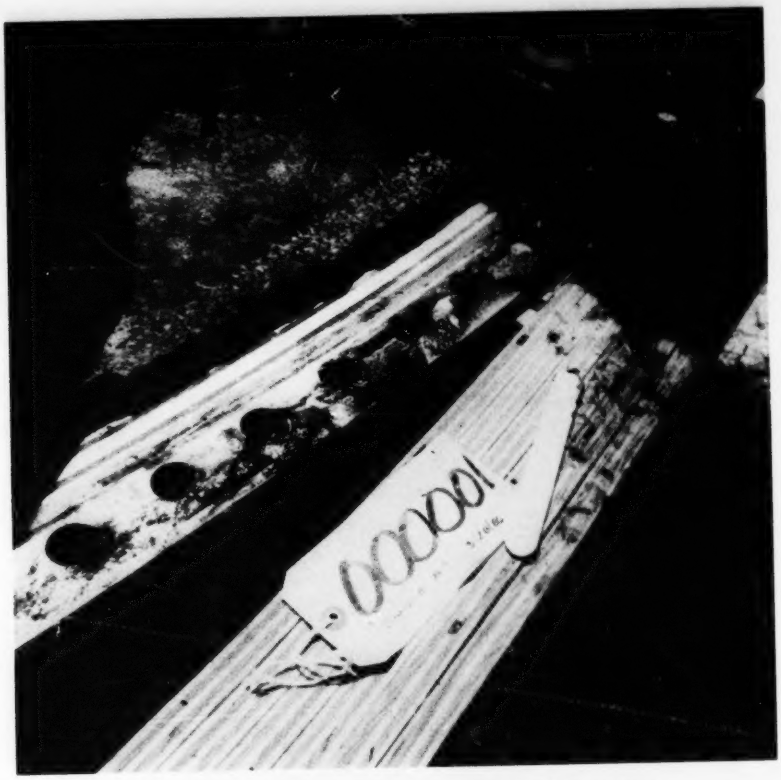
Photograph 17. Drawing of Intertank Portions of ET Recovered


-Z
+Y
+Z
-Y
-Z
LH2 TANK

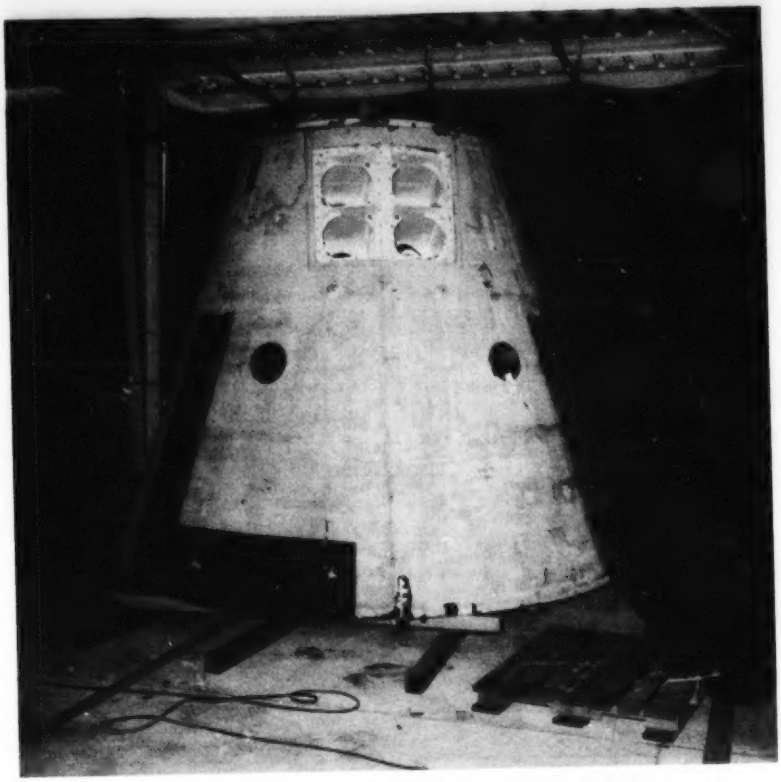
Photograph 18. Drawing of LH_2 Portions of ET Recovered

Photograph 19. Condition of SRB Prior to Burning of Residual Propellant

Photograph 20. Condition of SRB After Burning of Residual Propellant



Photograph 21. Tang of SRB Field Joint
Note O-Ring Seal Tracks



Photograph 22. Left-Hand SRB Frustum

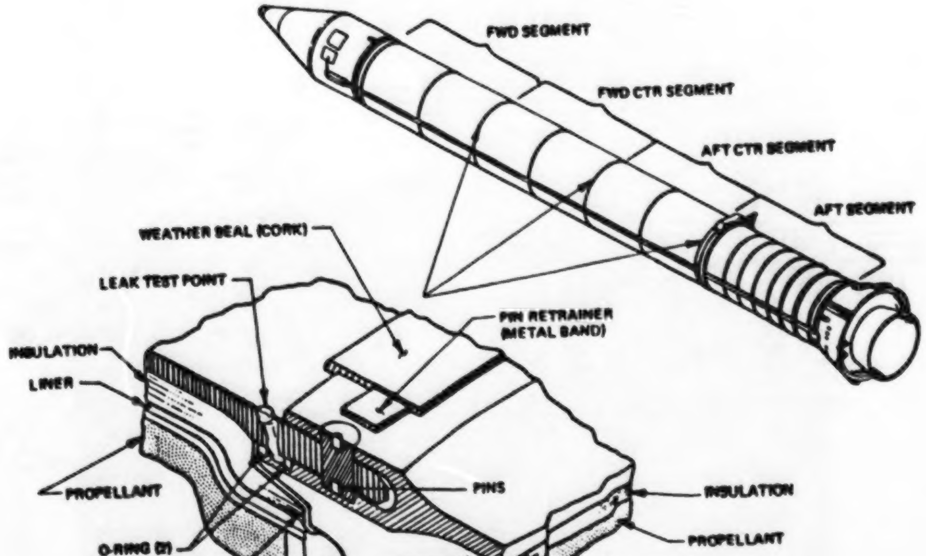

FWD SEGMENT
FWD CTR SEGMENT
AFT CTR SEGMENT
AFT SEGMENT
WEATHER SEAL (CORK)
LEAK TEST POINT
PIN RETRAINER (METAL BAND)
INSULATION
LINER
PROPELLANT
PINS
INSULATION
PROPELLANT
O-RING (2)
ZINC CHROMATE PUTTY

Figure 22. Solid Rocket Motor and Typical Field Joint

SRB COORDINATE SYSTEM

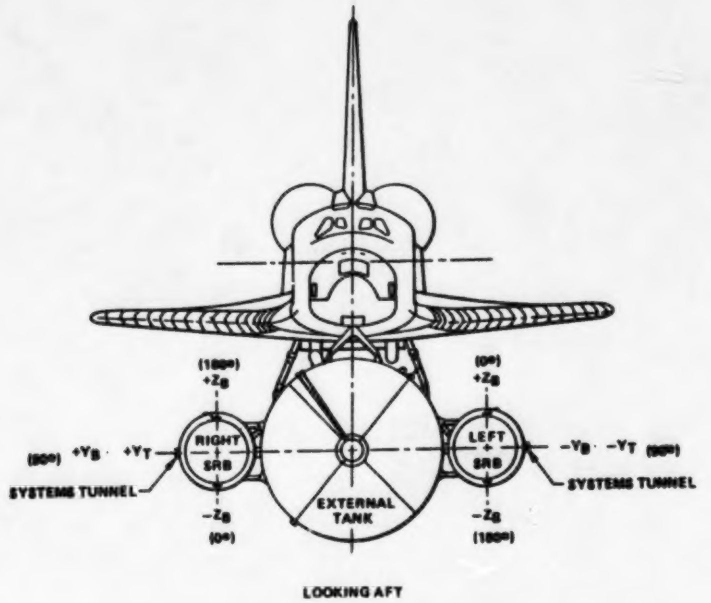

(180°)
$+Z_B$
RIGHT
SRB
(90°) $+Y_B$ · $+Y_T$
SYSTEMS TUNNEL
$-Z_B$
(0°)
(0°)
$+Z_B$
LEFT
SRB
$-Y_B$ · $-Y_T$ (90°)
SYSTEMS TUNNEL
$-Z_B$
(180°)
EXTERNAL
TANK
LOOKING AFT

FIGURE 23

Space Transportation System

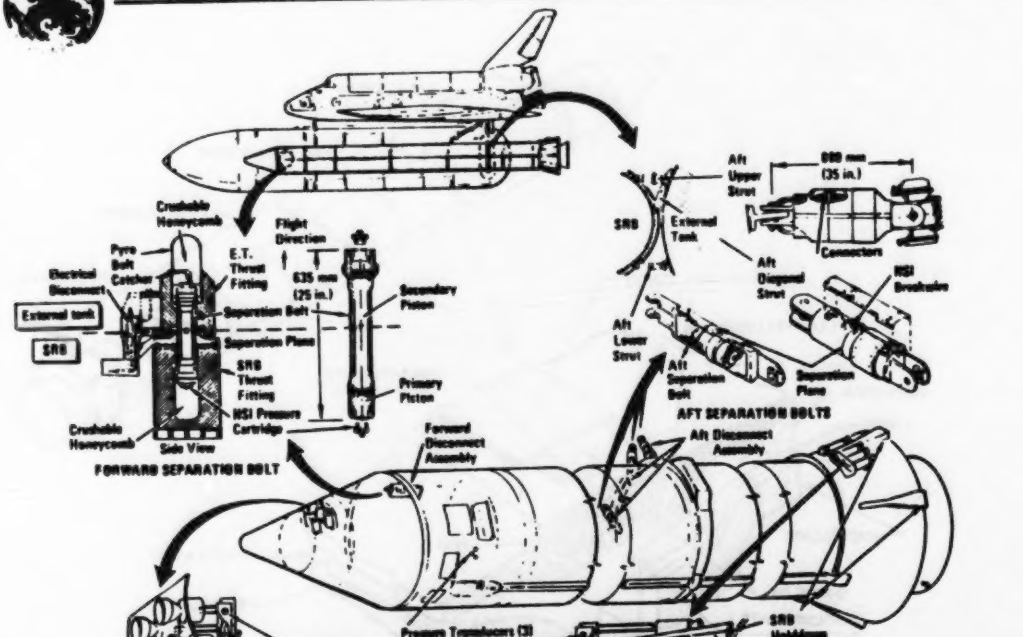
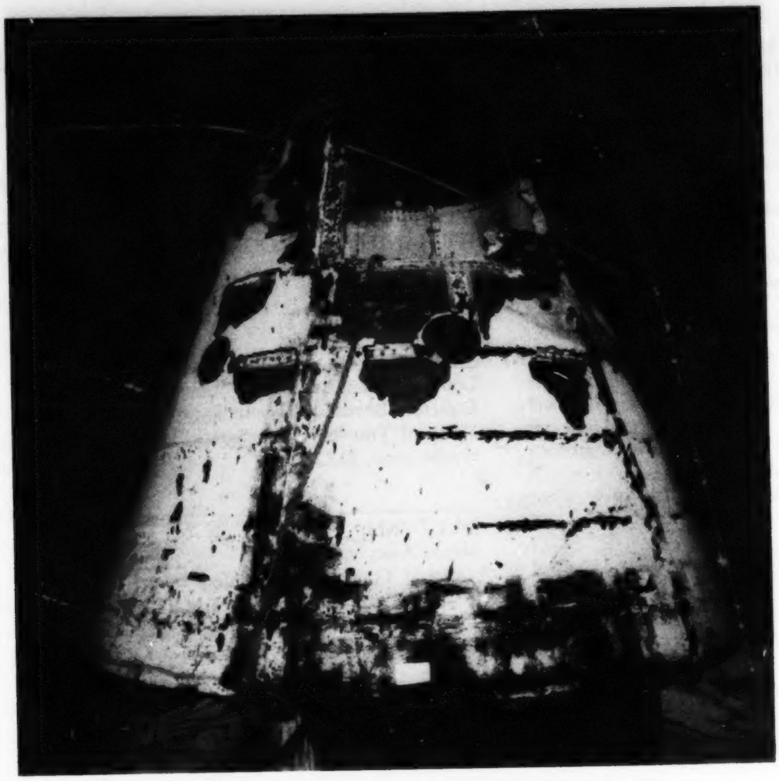
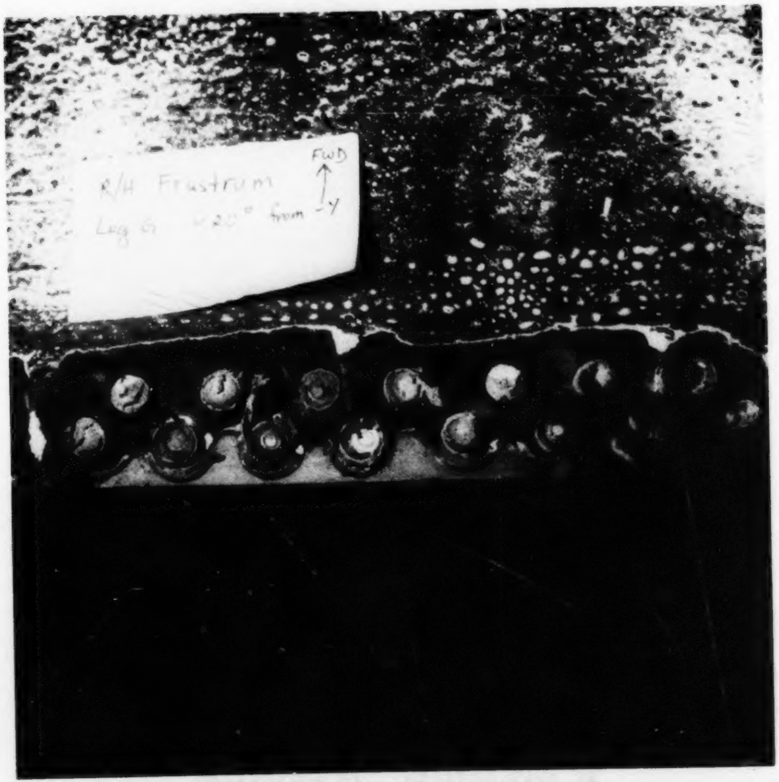

Crushable Honeycomb
Pyro Bolt Catcher
Electrical Disconnect
External tank
SRB
E.T. Thrust Fitting
Separation Bolt
Separation Plane
SRB Thrust Fitting
NSI Pressure Cartridge
Crushable Honeycomb
Side View
FORWARD SEPARATION BOLT
Flight Direction
635 mm (25 in.)
Secondary Piston
Primary Piston
Forward Disconnect Assembly
Aft Upper Strut
889 mm (35 in.)
SRB
External Tank
Connectors
Aft Diagonal Strut
NSI Breakwire
Aft Lower Strut
Aft Separation Bolt
Separation Plane
AFT SEPARATION BOLTS
Aft Disconnect Assembly
Pressure Transducers (3)
Confined Detonating Fuse
SRB Holddown Post
Support Post
FORWARD BOOSTER SEPARATION MOTORS
AFT BOOSTER SEPARATION MOTORS

Figure 24. Separation System Elements



Photograph 23. Right-Hand SRB Frustum


R/H Frustrum
Leg 61 ~20° from -Y
FWD

Photograph 24. Closeup View of
Right-Hand SRB Frustum Where ET Contacted

CONTACT #131 AND #712
RECOVERED RIGHT-HAND SOLID ROCKET BOOSTER AFT FIELD JOINT EVALUATION

May 8, 1986

APPROVED BY: ______________________________

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National Transportation Safety Board
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APPROVED BY: ______________________________

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National Transportation Safety Board

ENCLOSURE 9

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CONTACT NUMBERS 131 AND 712 RECOVERED RIGHT-HAND SOLID ROCKET BOOSTER AFT FIELD JOINT EVALUATION

A. *ACCIDENT*

Location: Atlantic Ocean near the Kennedy Space Center, Florida

Date: January 28, 1986 at 11:39 EST

Vehicle: Space Transportation System, Mission 51-L, Challenger

Operator: National Aeronautics and Space Administration

B. *STRUCTURAL EVALUATION GROUP*

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C. *SUMMARY*

The structural evaluation of right-hand (RH) Solid Rocket Motor (SRM) pieces, sidescan sonar contact (SSC) Nos. 131 and 712, established conclusively that propellant fire burned a large hole (about 6 square feet) in the side of the SRM and that the hole was centered approximately about the 305-degree position of the lower field joint. The propellant flame exhausted through the hole in the RH SRM, breached the Liquid Hydrogen (LH_2) tank, and destroyed its structural integrity.

It is believed that the fire also separated the aft lower External Tank (ET) attachment strut connection to the ET which partially released the RH Solid Rocket Booster (SRB) from the ET. Following its partial release, the right SRB probably rotated and yawed sufficiently about its remaining ET attachment connections for the base of its frustum to forcefully contact and penetrate ET intertank structure. The losses of structural integrity in the LH_2 tank and in the aft lower ET attachment connection led directly to the destruction of STS 51-L.

The propellant fire burned through the RH SRM case most probably because the two O-ring seals in the lower field joint failed to contain internal combustion pressure which permitted the fire to burn abnormally toward and into the joint; however, because of thermal destruction of the seals and joint, this probability could not be conclusively verified by physical evidence.

D. *INTRODUCTION*

In late April 1986, two pieces of the RH SRM from Space Transportation System (STS) Mission 51-L were recovered from the Atlantic Ocean and were transported to Hangar "O" at the Cape Canaveral Air Force Station (CCAFS) for evaluation. These two pieces of SRM were identified by the Recovery Support Team as Sidescan Sonar Contact (SSC) Numbers 131 and 712. Because of the evident burn damage on these two pieces, they were evaluated separately from the other 40 pieces of SRM recovered.

Since the pieces of SRM were too large and heavy to maneuver into positions to match fracture surfaces, full size styrofoam templates were made of many pieces of the RH SRM, and the templates were arranged in a two-dimensional pattern to match fracture surfaces. (Reference Photograph 1.)

E. *STRUCTURAL EVALUATION*

The RH SRM pieces identified as SSC Nos. 131 and 712 were evaluated at Hangar "O" (see Photographs 2 and 3). The propellant on these two pieces of SRM was not removed by burning on the Explosive Ordnance Disposal (EOD) Range to avoid any risk of damage to the pieces (see Photograph 4).

The base of the SSC No. 131 piece contained the tang portion of the lower field joint and extended from the 264-degree position clockwise to the 90-degree position, about 238 inches circumferentially. The piece varied irregularly in height from approximately 71 inches at the 264-degree position to about 132 inches at the 90-degree position. The piece was similar to other pieces of SRM recovered with regard to the presence of unburned propellant and the condition of the exterior surface and insulation, except for an irregular oblong-shaped area about 15 inches high by approximately 28 inches long that was missing along its base. Also, sooting and blistered paint were evident on the exterior surface of the SRM surrounding the missing area. The base of the missing area was centered about the 305-degree position, and the steel case around the area was melted and eroded from exposure to heat (see Photograph 5).

A 17-inch crack in the SRM case extended from the upper left corner of the missing area (see Photograph 6). Examination of the crack surfaces disclosed no evidence of thermal erosion which indicates that the crack developed after propellant burning had ceased—probably on impact with the surface of the Atlantic Ocean.

The piece of RH SRM identified as SSC No. 712 extended circumferentially from about the 226-degree position clockwise to the 320-degree position, and it varied irregularly in height from about 60 inches at the former position to about 72 inches at the latter position. The base of the piece was a tang portion of the forward stiffener-to-External Tank (ET) attachment joint at X_B 1577.5. The tang of this piece is used in a factory joint. The upper part of the piece contained portions of the ET attachment ring stubs (see Photograph 3).

The upper left edge of piece SSC No. 712 was burned and eroded from the 291-degree position to the 318-degree position, approximately 33 inches circumferentially (see Photograph 7). This portion of the piece also contained a burn hole about 4 inches long by 1.5 inches high, just above a portion of the ET attachment ring lower stab (see Photograph 8).

Hardness tests were made in the SRM case material surrounding the burned edges of both pieces of SRM. These tests showed normal hardness values for D6AC steel except within about 5 inches of the burned edges where the values showed thermal degradation. Also, the area between the ET attachment ring stubs on No. 712 was thermally degraded.

Full-size templates of the SSC Nos. 131 and 712 pieces were made and placed in their relative two-dimensional positions (see Photograph 9), and a drawing was made of the two pieces in their relative two-dimensional position (see Figure 1). Calculations based on the dimensions of the areas missing from and between the two pieces indicate that the missing areas represented about 862 square inches (about 6 ft^2) of SRM case including about 28 circumferential inches of the lower field joint. Based on the evidence provided by these two pieces of the RH SRM, it is concluded that propellant fire burned a hole through the case of the SRM and that the approximate size of the hole was 6 square feet when the burning ceased.

Since the burned-out areas of the RH SRM included about 28 circumferential inches of the lower field joint, the evidence related to the most probable reason for the development of a propellant flame path . . . to and through the SRM case—a combustion pressure leak past the O-ring seals in the field joint—was consumed by the hot propellant flame (about 5,600°F). However, because of the thermal destruction of the field joint including the O-ring seals, other possible sources of a combustion pressure leak could not be excluded by the physical evidence. Consequently, additional supporting evidence is needed to conclusively establish that failures of the O-ring seals to contain internal combustion pressure permitted propellant fire to follow a pressure leak path to and through the SRM casing and to initiate the destruction of STS 51-L.

In order to portray the burned-out areas of the RH SRM case, as established by pieces SSC Nos. 131 and 712 in relationship to other SRM structure, an outline of the areas was drawn on the side of a RH aft SRB field joint area that was located in the Vehicle Assembly Building (VAB) at the Kennedy Space Center (see Photograph 10). As can be seen from this portrayal, the lower left portion of the missing areas included case material behind the ET attachment ring in the vicinity of the aft lower ET attachment strut. Also, the lower portion of the LH_2 tank in the ET was in close proximity (about 2 feet) to the hole burned in the side of the SRM. Consequently, it is concluded that the LH_2 tank was penetrated by the propellant flame exhausted through the hole. Further, the small hole in the SRM case near the lower ET attachment ring stub was burned by fire deflected inward, probably by the attachment strut connection to the ET attachment ring. It is concluded that the ET attachment strut separated at its ET connection. Finally, separation of the aft lower ET attachment strut probably allowed the RH SRB to rotate and yaw sufficiently about its remaining ET connections for the base of the SRB Frustum to forcefully contact and penetrate the ET intertank structure. Therefore, it is concluded that the partial separation of the RH SRB at its aft lower attachment strut connection to the ET and the breach of the LH_2 tank lead directly to the destruction of STS 51-L.

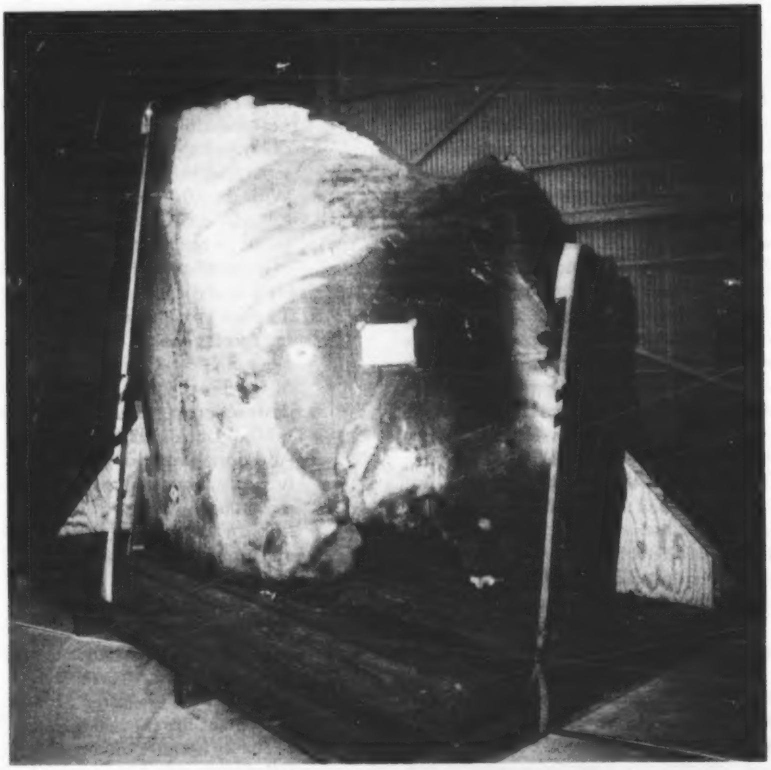
F. *FINDINGS*

1. Hot propellant flame burned a hole through the side of the RH SRM that was centered near the 305-degree and X_B 1496 position of the SRM; the hole included about 6 square feet of SRM case and about 28 circumferential inches of the lower field joint when the burning ceased.
2. A 1.5-inch by 4-inch hole was burned from the outside of the SRM case inward and through the case near the lower stub of the ET attachment ring; the hole was burned by hot propellant flame deflected inward probably by the aft lower ET attachment strut connection to the ET attachment ring.
3. Hot propellant flame exhausted from the hole in the RH SRB burned and penetrated the LH_2 tank in the ET near the aft lower ET attachment strut connection which destroyed the structural integrity of the LH tank and separated the lower attachment strut connection.
4. With the aft lower attachment strut separated from the ET, the SRB probably rotated and yawed sufficiently about its remaining attachment connections for the base of the frustum to forcefully contact and penetrate ET intertank structure.
5. The hot propellant flame burned through the SRM casing most probably because of a combustion pressure leak across the two O-ring seals near the 305-degree position of the lower field joint; however, because of thermal destruction of the seals and joint, this probability could not be conclusively verified by the physical evidence.
6. Additional supporting evidence is needed to conclusively verify that sealing failures of the two O-rings caused a combustion pressure leak that permitted propellant fire to burn toward and through the case of the RH SRM and to initiate destruction of STS 51-L.

G. *CONCLUSIONS*

1. The destruction of STS 51-L was caused by propellant fire that burned through the case of the RH SRM and destroyed the structural integrity of the LH_2 tank and separated the aft lower SRB-to-ET attachment strut.
2. Propellant fire burned through the RH SRM case most probably because the two O-rings in the lower field joint failed to contain internal combustion pressure which permitted the fire to burn abnormally toward and into the joint; however, because of thermal destruction of the seals and joint, this probability could not be conclusively verified by the physical evidence.

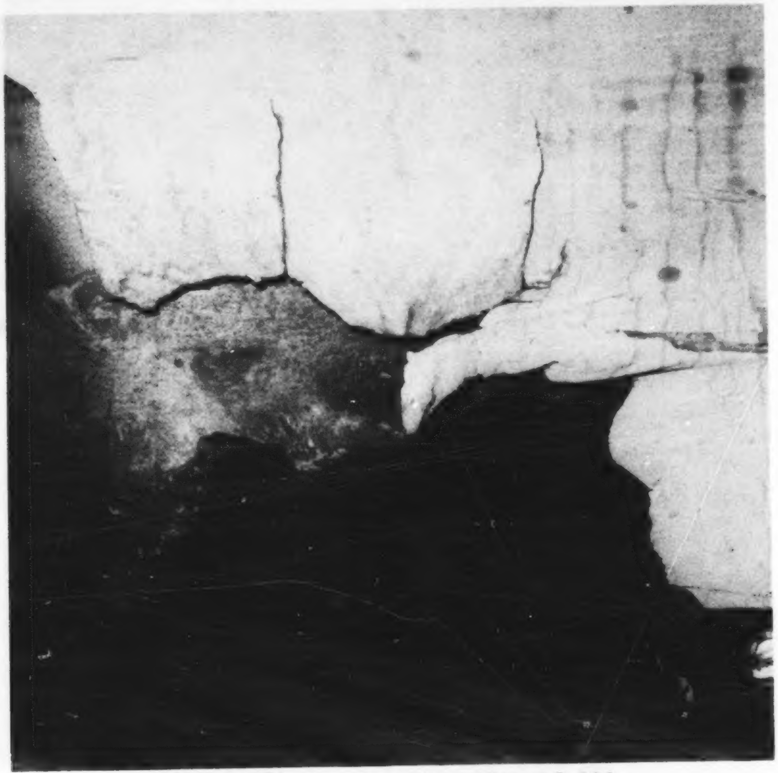
Photograph 1. Full-Size Templates of Right SRM Pieces. Note SSC Nos. 131 & 712 at Center of Photograph



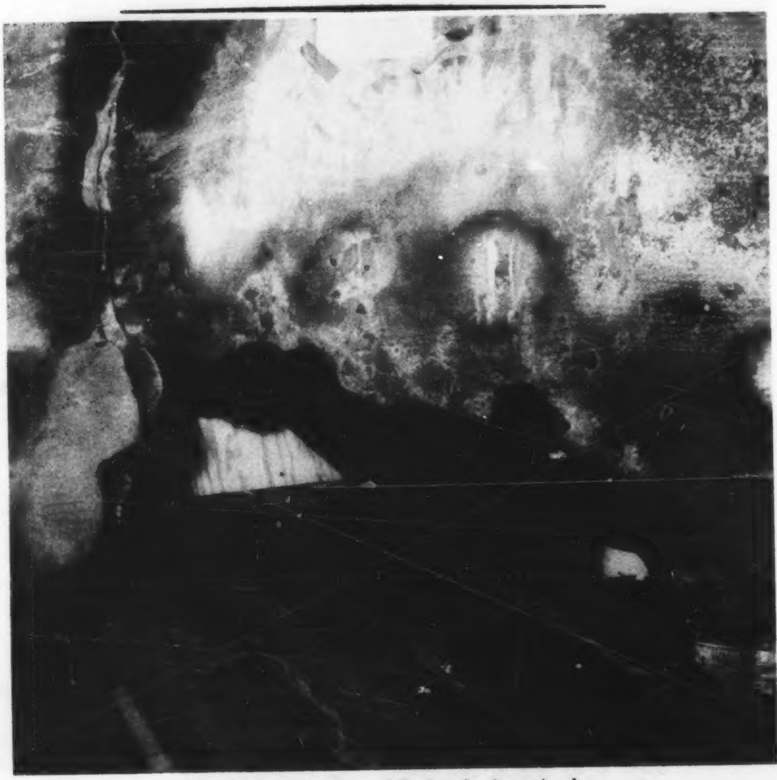
Photograph 2. Exterior View of Piece of Right SRM, SSC No. 131. Note Burned-Out Area at Base

Photograph 3. Exterior View of Inverted Piece of RH SRM, SSC No. 712. Note Burned-Out Area in Lower Right Corner

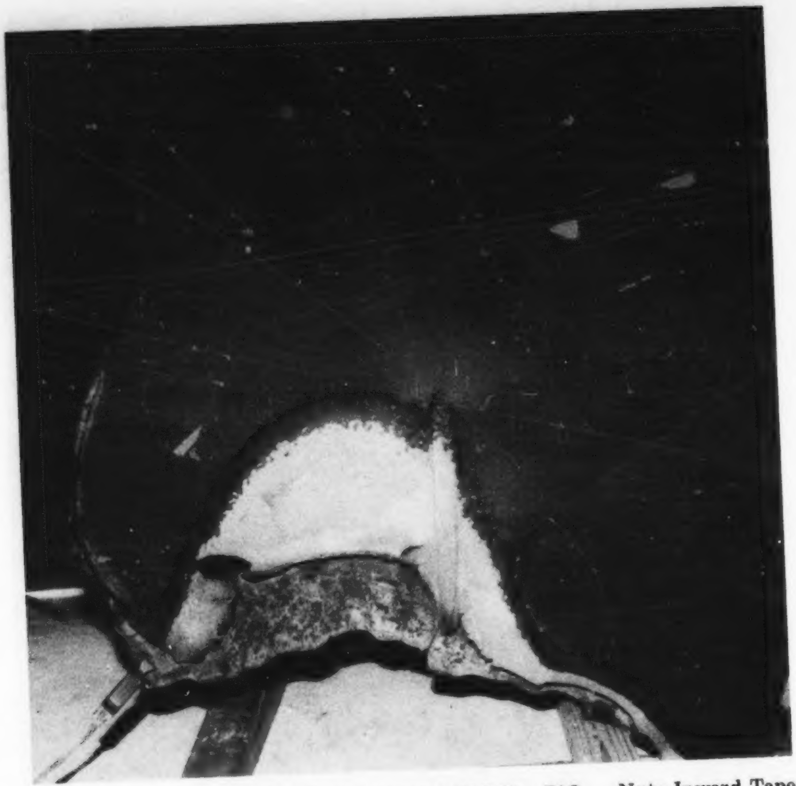
Photograph 4. Interior View of SSC No. 131 Showing Propellant. Note Burned-Out Area in Lower Left Corner



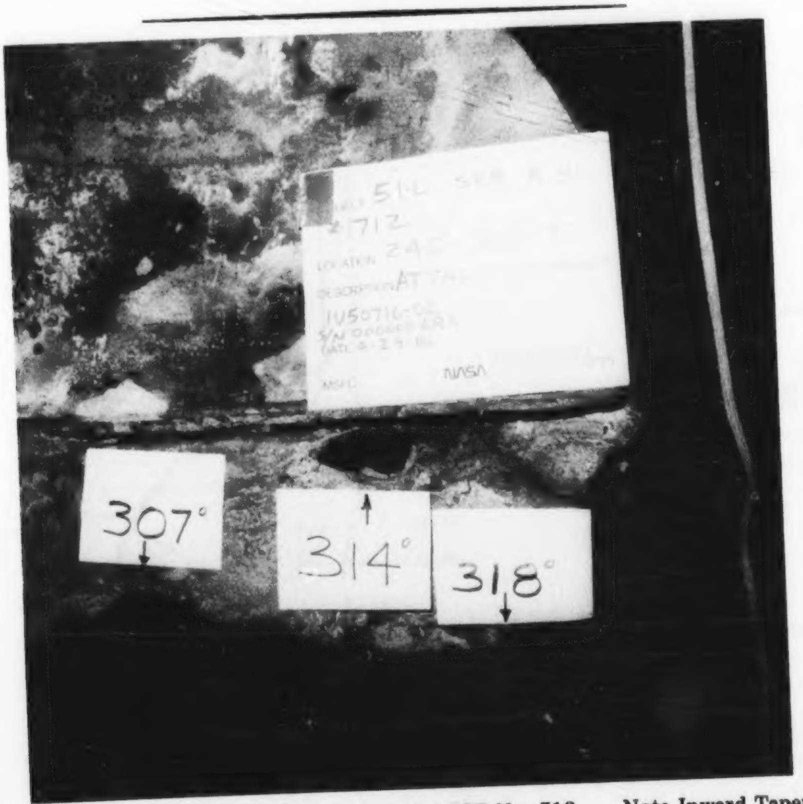
Photograph 5. Interior View of SSC No. 131 Piece. Note Tapered Edges of Casing Indicating Burn-Through from the Inside to the Outside



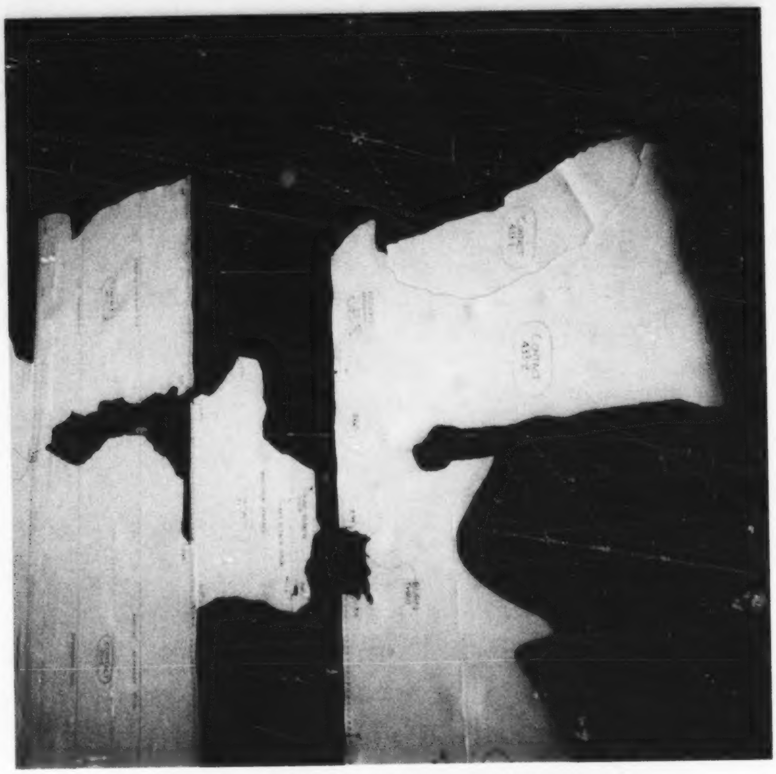
Photograph 6. 17-Inch Crack in SSC No. 131



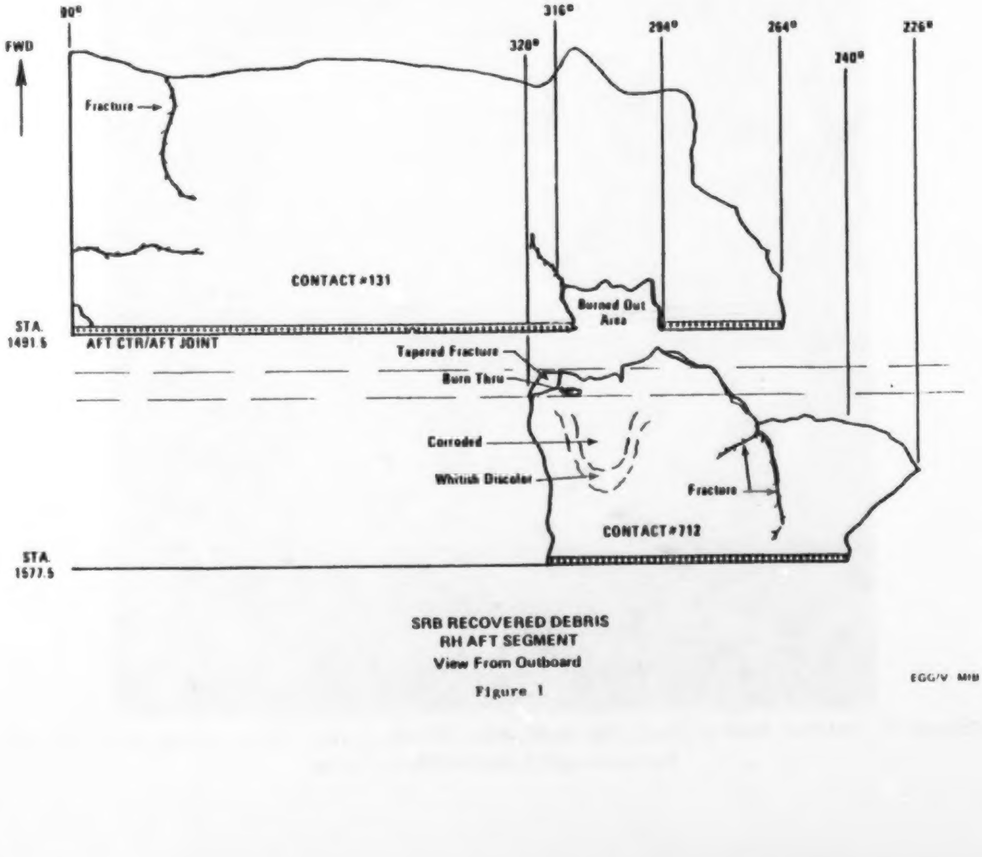
Photograph 7. Interior View of Small Hole in Inverted SSC No. 712. Note Inward Taper Indicating Burn-Through from Outside to Inside.


51-L
#712
LOCATION
DESCRIPTION
1U50716-02
S/N
DATE
MSFC
NASA
307°
314°
318°

Photograph 8. Exterior View of Small Hole in Inverted SSC No. 712. Note Inward Taper Indicating Burn-Through from Outside to Inside.



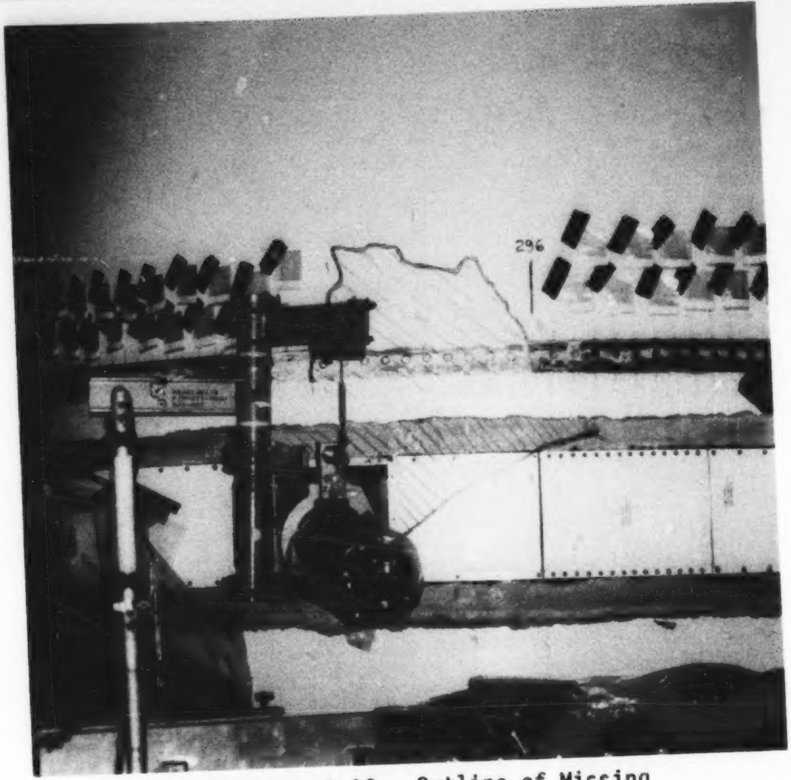
Photograph 9. Relative Positions of SSC Nos. 131 and 712


90°
316°
294°
264°
226°
320°
240°
FWD
Fracture
CONTACT #131
Burned Out Area
STA. 1491.5
AFT CTR/AFT JOINT
Tapered Fracture
Burn Thru
Corroded
Whitish Discolor
Fracture
CONTACT #712
STA. 1577.5

SRB RECOVERED DEBRIS
RH AFT SEGMENT
View From Outboard

Figure 1

EGG/V MIB 25



Photograph 10. Outline of Missing Areas of SSC Nos. 131 and 712 on RH SRB of 61-G